COMBUSTION

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Looking up toward the roof tubes of an 1800-lb. steam generating unit

Steam Chosen over Diesels for Municipal Plant

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Fusion Characteristics of Fractionated Coal Ashes

COMBUSTION

VOLUME FIVE • NUMBER FOUR

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FOR OCTOBER 1933

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EDITORIALS

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EDITORIAL

Mechanical Engineering Projects Entitled to Government Aid

INSPIRED by a well-known equipment manufacturer, a campaign has been launched by the technical press for extension of the Public Works Program to the modernization of mechanical equipment in public buildings.

So far the approved projects have dealt largely with civil engineering. These will benefit a large group of unskilled labor, contractors, civil engineers and manufacturers of certain bulk materials. But the spirit, as well as the language, of the Recovery Act is broad and applies equally to projects of a mechanical nature. Inclusion of such in the program would stimulate business for equipment manufacturers and benefit local skilled labor as well as many mechanical engineers who, as a class, have suffered keenly by the depression. A diversity and wide spread of employment would thus be achieved.

The case for the public buildings, as concerns heating, ventilation, air conditioning, elevators, etc., has already been so thoroughly presented in the campaign that further observations would be mere reiteration. It may be well, however, to direct attention to another phase of the situation that has not been so well stressed. This pertains to the power and other services in state institutions such as prisons, asylums, hospitals, etc. About two years ago New York State undertook a program of rehabilitation of such services in its public institutions with large resulting saving. Ohio followed shortly thereafter and thereby effected operating savings of nearly two million dollars annually. Pennsylvania is now engaged in a similar program. But in many other states there is still urgent need for such rehabilitation.

If well planned and discretely applied, such projects would eliminate waste without adding to productive capacity, and such use of federal funds would be far-reaching. To receive due consideration by the Public Works Administration the idea must be pressed by all concerned. A committee of the A.S.M.E. has been appointed to assume the leadership.

Minimum Setting Heights When Using Solid Fuel

EVENTS of the past few months point to definite progress toward establishing rational minimum setting heights for steam heating boilers using solid fuel. Prior to June of this year there were in existence several tables of recommended setting heights, compiled individually by the Stoker Manufacturers Association, the Steel Heating Boiler Institute, the Midwest Stoker Association and several local smoke abatement departments. These differed in many essentials, as a result of which both boiler and stoker manufacturers were often handicapped.

An attempt last year by the A.S.M.E. Pure Air Committee to reconcile these differences focussed attention on the situation and finally led to the matter being placed under the procedure of the American Standards Association with the A.S.M.E. acting as sponsor. This plan was accepted by the several interests concerned and late in June a committee on the Unification of Rules was appointed. This committee, representing about a dozen associations in the boiler, stoker, heating, smoke abatement and mechanical engineering fields, is now organized and functioning.

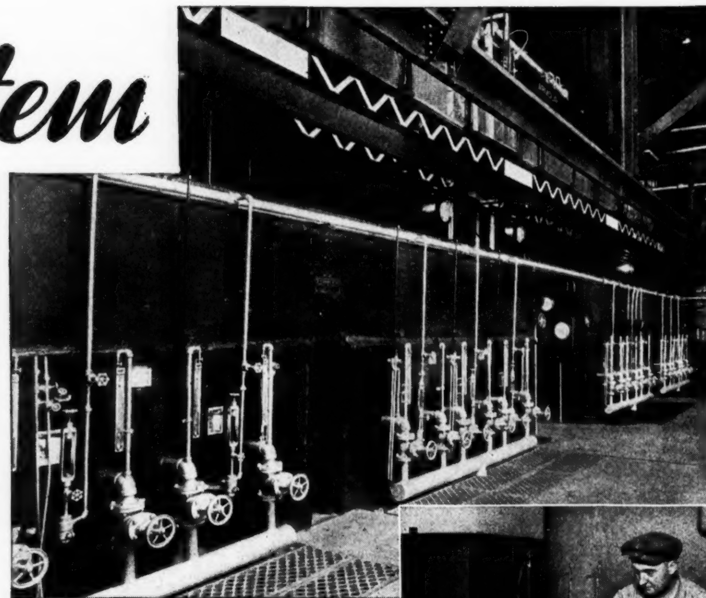
Owing to the diversity of fuel characteristics and other factors, such as load and local conditions, rigid standards are likely to prove impracticable; but the establishment of certain minimum dimensions for given coals will remove much of the confusion that now exists. Obviously, such standardization will not affect larger boilers of the power generation class.

The encouraging sign is that all parties concerned have been brought together in agreement to cooperate with and follow the recommendations of the committee.

Rising Fuel Prices Demand Better Efficiency

AFTER much bickering the bituminous coal industry has fallen into line and accepted an NRA Code. This portends an early advance in coal prices. Inasmuch as the oil and gas industries have already signed up, steam users are faced with increased fuel cost, except those who happen to be protected by favorable contracts having a considerable time to run. The only way to offset this increase in fuel prices is through more efficient steam generation.

With fuel prices at such low levels as have prevailed for months past there was little or no incentive to make any expenditure for efficient equipment. Now the situation has changed and will become more urgent as production increases. With wages and cost of materials advanced, conditions of labor prescribed and price levels established, management must look to economies in operation as a means toward securing increased profits, The fuel bill, in many cases, offers a source for substantial savings. There is no dearth of steam generating capacity throughout industry, but several years of intensive production followed by four years of progressive inactivity, have rendered much of this equipment out of date.



Steam Chosen over Diesels for Municipal Plant

By C. F. LAMBERT,
Burns & McDonnell Engineering Co.
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An analysis of load conditions, probable growth in load and bids submitted by manufacturers of both steam and diesel equipment led to the selection of steam for the Piqua, Ohio, municipal plant. While the figures for the first year slightly favored diesels, comparison over a five-year period favored steam. The boiler plant is described and a table of the principal equipment appended.

A CONSIDERABLE part of the work of this organization is the design of electric power stations and the preparation of reports as to the feasibility of municipal power plants for various cities. In these preliminary reports it is usually found desirable to consider the use of both steam and diesel plants and to determine the type best adapted to the particular conditions found in each case. Such determinations must take into account, first cost, load conditions, size of units and cost of fuel.

Usually the type of plant is determined entirely on the basis of estimates made in the preliminary report. At Piqua, Ohio, however, it was decided to receive bids on both types of equipment and make the decision on the basis of actual prices bid and guaranteed operating data. The preliminary report in this case showed very little difference as between the two types and therefore at the request of the city officials, bids on both types were taken as mentioned above.

Preliminary Report

The population of Piqua, Ohio, is 16,000. The investigation showed that there were 5500 consumers; the consumption of current was 11,000,000 kw-hr.; and the peak load 3400 kw. It was assumed that in five years the population would increase to 16,900; the number of consumers would increase to 5830; the consumption would increase to 13,992,000 kw-hr. and the peak load to 4290 kw.

For the steam plant, four combinations of units were studied as follows:

Four 1250-kw. units
Three 2500-kw. units
Two 4000-kw. units
Two 5000-kw. units

Taking into consideration, reserve capacity, first cost and economy under the load conditions anticipated, the two 4000-kw. units were found to meet the requirements most economically.

For the diesel plant, three combinations of units were studied as follows:

Four 1250-kw. units
Four 1600-kw. units
Three 2500-kw. units

Taking into consideration the same factors as above, the four 1250-kw. units were found best to meet the requirements. Due to the fact that the economy of different sized diesel units is more uniform than with steam turbines, it is possible to keep the total plant capacity at a lower figure and still have ample reserve capacity. The estimated cost of the two types of plants was as follows:

Steam Plant	
Building	$82,000
Boiler Room Equipment	155,500
Turbine Room Equipment	259,000
Total	$496,500
Cost per kilowatt installed	$ 62.00

It may be interesting to know that this plant was actually purchased for $421,916. This saving was accomplished even though the plant upon which bids were received was based upon a higher pressure and superheat than that contemplated in the preliminary report. The plant is to operate at 400 lb. pressure with 200 deg. superheat.

Diesel Plant	
Building	$56,500
Equipment	404,000
Total	$460,500
Cost per kilowatt installed	$ 92.00

The estimated operating cost for the two types of plant was as follows:

Non-Variable Costs

Item	Steam	Diesel
Plant labor	$12,600	$10,000
Maintenance	12,500	7,200
Insurance	2,000	1,800
Total	$27,100	$19,000

The steam plant was based on 300 lb. pressure and 150 deg. superheat, and, with coal at $3.50 per ton, the average annual fuel cost for the first five years was estimated at $78,500.

With fuel oil at 4 cents per gallon and lubricating oil at 50 cents per gallon, the average annual fuel cost for the first five years for the diesel plant was estimated at $61,190.

The total estimated cost of the two plants, including the distribution systems, engineering and miscellaneous costs, was

Steam plant	$803,200
Diesel plant	765,500

The total annual costs are then shown in the following table.

	Steam	Diesel
Plant costs except fuel	$27,100	$19,000
Fuel	78,500	61,190
Other operating costs	23,600	23,600
Total operation	$129,200	$103,790
Interest and depreciation, 11 per cent	88,352	84,205
Total annual costs	$217,552	$187,995
Cost per kw-hr. sold	1.97	1.71

This would seem to show considerably in favor of the diesel plant. However, the diesel plant has a total capacity of 5000 kw. and the steam plant a total capacity of 8000 kw. This means that with an increasing capacity requirement the diesel plant will need additional equipment before the steam plant does.

With this in mind an additional study was made to determine what effect the surplus would have on future additions as follows:

Diesel Plant:

Surplus at end of eight years	$631,820
Interest on surplus	71,221
Total cash	$703,041
This could be used as follows:	
Addition to building	52,500
Equipment complete, 2—2500-kw. units	550,000
Addition to distribution system	100,500
Total	$703,000
Total capacity of plant—10,000 kw.	
Value of plant on earning basis, 6% interest and 4% depreciation	$2,461,720

Steam Plant:

Surplus at end of eight years	$320,105
Interest on surplus	18,869
Total cash	$338,974
This could be used as follows:	
Addition to building	$31,500
Equipment complete, 1—2500 kw. unit	207,000
Addition to distribution system	100,500
Total	$339,000
Total capacity plant—10,500 kw.	
Value of plant on earning basis, 6% interest and 4% depreciation	$2,266,240

Bids Received

When specifications were prepared, it was decided to receive bids on several different sized units and several combinations of units for both steam and diesel plants.

Bids were received as follows:

Steam:	*Diesel:*
(1)—2—4000 kw. units	(1)—4—1250 kw. units
(2)—2—3000 kw. units	(2)—5—1250 kw. units
(3)—3—2500 kw. units	(3)—4—1600 kw. units
(4)—1—4000 kw. units	(4)—1—2500 kw. units
	3—1250 kw. units
(5)—1—3000 kw. units	(5)—2—2500 kw. units
	1—1250 kw. units
(6)—1—2500 kw. units	(6)—1—1250 kw. units
	(7)—1—1600 kw. units
	(8)—1—2500 kw. units

In connection with the steam plant bids were also received on condensers to correspond. The boiler bids were on the basis of two steam generating units of 50,000 lb. per hr. continuous capacity.

The bids were taken on these various sized units with the idea that some more favorable combination might be selected. However, it was found that the original selection was still the best, so all comparisons were made on the basis of two 4000-kw. steam units and four 1250-kw. diesel units.

Comparison of cost was made on the basis of items which were not common to both plants. The best bid for the steam plant was $408,076 and for the diesel plant $352,200. All the diesel bids were compared, taking into consideration the size of building required, cost of foundation and other items which varied with each make of engine.

The steam plant fuel considered was 11,000 B.t.u. coal, costing $3.00 per ton. Fuel oil for the diesel plant was taken at 4 cents and lubricating oil at 50 cents per gal.

The comparison was made on the basis of five years of operation, the yearly outputs being sufficient to provide for station consumption and line losses.

Fig. 1—Piqua Station nearing completion

First year	13,243,000 kw-hr. generated
Second year	14,093,800 kw-hr. generated
Third year	14,973,400 kw-hr. generated
Fourth year	15,869,000 kw-hr. generated
Fifth year	16,714,800 kw-hr. generated

The guaranteed economy of diesel engines on the lowest bid submitted was:

100% load 0.579 lb. oil per kw-hr.
75% load 0.608 lb. oil per kw-hr.
50% load 0.658 lb. oil per kw-hr.
25% load 0.940 lb. oil per kw-hr.

Some bids showed better economy but fixed charges were greater.

The steam consumption guarantees for the lowest bid submitted for turbine units were:

2000 kw.—10.93 lb. per kw-hr.
3000 kw.—10.60 lb. per kw-hr.
4000 kw.—10.50 lb. per kw-hr.
5000 kw.—10.54 lb. per kw-hr.

Final analysis showed the following:

First Year:

	Steam	Diesel
Fuel & lubrication	$33,450	$46,910
Labor	12,600	10,000
Maintenance	12,500	7,200
Insurance	2,000	1,800
Total	$60,550	$65,910
Interest and depreciation 10 per cent	40,808	35,220
Total annual charges	$101,358	$101,130
Cost over steam, first year		$-228
Installed cost per kw.	51.01	63
Operating cost per kw-hr.	4.56 mills	4.97 mills
Annual cost per kw-hr. with interest and depreciation	7.65 mills	7.63 mills

Second Year:		
Total annual charges	$103,088	$103,424
Cost over steam, second year		336
Cost over steam, two years		108
Third Year:		
Total annual charges	$105,358	$106,363
Cost over steam, third year		1,005
Cost over steam, three years		1,113
Fourth Year:		
Total annual charges	$107,208	$109,467
Cost over steam, fourth year		2,259
Cost over steam, four years		3,372
Fifth Year:		
Total annual charges	$109,108	$112,038
Cost over steam, fifth year		2,930
Cost over steam, five years		6,302

From this it will be seen that the diesel engine showed the best result for the first year, but that, as the load factor improved and the steam plant was operating at more economical points, the balance was increasingly in favor of steam.

Description of Boiler Plant

Due to the character of the plant site, the entire station has been built above grade. The operating floor for the stokers, boilers, fans and main turbines is at the same elevation, and there is no partition wall between the boiler and turbine rooms.

The two steam-generating units are identical and consist of bent-tube boilers with welded drums designed for 400 lb. pressure and have a maximum capacity of 60,000 lb. of steam per hr. each. They are fired with forced-draft chain-grate stokers, each having an effective grate area of 187 sq. ft. The stokers are driven by 3-hp. constant-speed motors which are connected to variable-speed drives mounted directly on the stoker transmission gear casing.

Referring to Fig. 3, the nose of the bridgewall is pro-

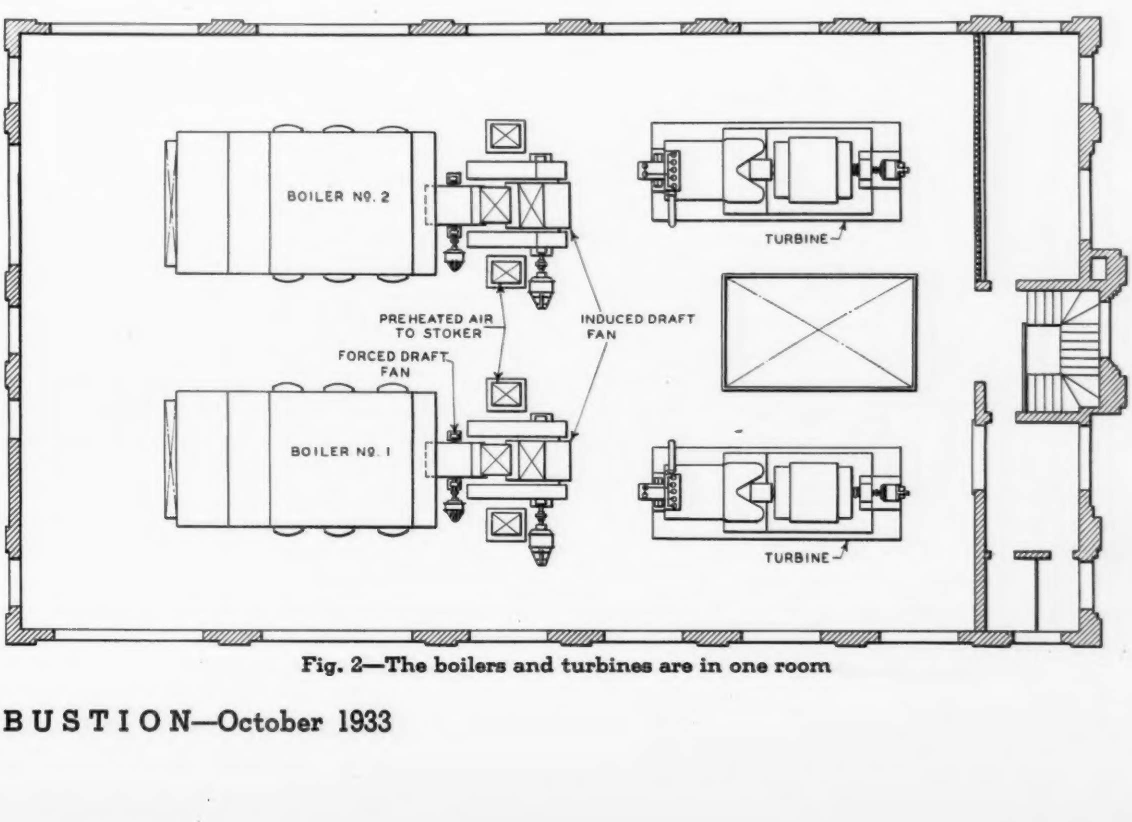


Fig. 2—The boilers and turbines are in one room

tected by a waterback extending across the full width of the furnace and is connected to the boiler circulation by means of downtake tubes from the mud drum and riser tubes to the upper front boiler drum. The furnace side walls are protected by headers located directly above the stoker grate and extend the full depth of the furnace. Plain vertical tubes located between the rear of the arch and the face of the bridgewall, connecting into these headers at the lower end and into a collecting header at the upper end, also form a protection for the furnace side walls. These tubes are connected into the boiler circulation by means of downtake tubes leading from the mud drum into the bottom headers and riser tubes located on the inside face of the boiler walls leading from the upper headers to the front boiler drum.

A suspended ignition and flat arch forms the extension furnace for the stoker. The firebrick lining in the furnace, boiler and bridgewalls is bonded by means of a series of holding tile and hook bolts attached to structural steel. The furnace walls are steel cased and insulated with a layer of block insulation. The boiler and bridgewalls are lined with red brick on the outside and covered with a layer of block insulation between the fire and red brick. Part of the rear boiler wall forms a partition for the air heater casing; the remainder consists of an outer steel casing and an inner casing with a layer of block insulation between.

The boiler is baffled for three passes. After leaving the boiler, the products of combustion pass into a tubular air preheater located at the rear of the boiler above the fans. From the preheater, the gases pass into an induced-draft fan located directly in back of the boiler on the stoker operating floor and are discharged into a common overhead stack located in the center aisle between the boilers.

A forced-draft fan located directly behind each boiler in front of the induced-draft fan and on the same floor discharges air into the preheater; from the preheater hot air is discharged into ducts leading down under the

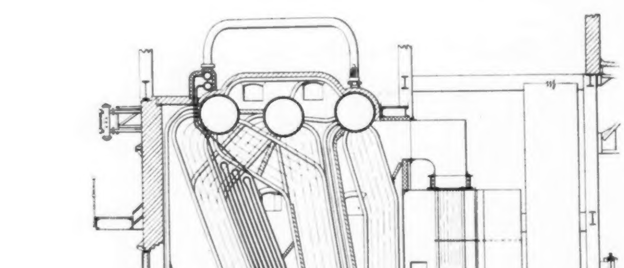


Fig. 3—Section through boiler showing furnace arrangement

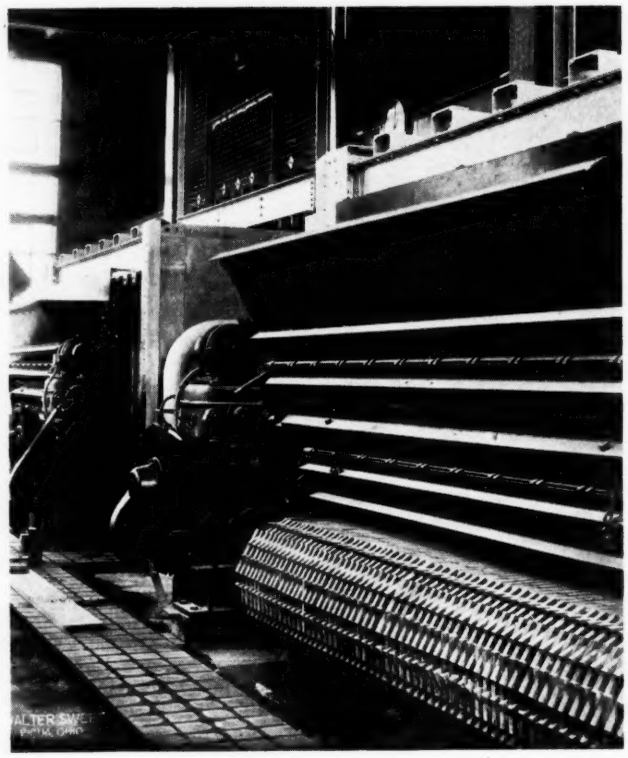


Fig. 4—View of stoker firing aisle

stoker on both sides of the unit. A portion of the ducts located underneath the floor has been designed as part of the structural steel, supporting the boiler side walls. Individual dampers control the preheated air to each of the six stoker compartments, thus enabling the operator to control the amount of air in each compartment as required.

Each boiler is equipped with a superheater located in the space between the first and second bank of boiler tubes. At maximum rating, 700-deg. steam at 383 lb. pressure will be delivered to a steam header located at the rear of the boilers.

Bituminous coal obtained from Ohio fields will be delivered to a track hopper and, by means of a skip hoist, discharged directly into a coal bunker located at one end of the boiler house. A weigh larry will distribute the coal to the coal hopper of each stoker. Each stoker is provided with a large-capacity, suspended, brick-lined ash hopper from which the ash is discharged into an ash car and in turn deposited into the skip hoist from which it is discharged into an overhead storage hopper located alongside of the coal bunker. A sifting hopper located at the front end of each stoker collects the fines carried forward by the stoker and is so designed that the fines can be discharged directly into a car located underneath the hopper.

Each boiler will be equipped with an instrument panel board located alongside of the building wall facing the boiler fronts. On each board will be mounted a steam gage, a ten-unit, multiple draft indicator, a two-pen recorder for steam temperature and pressure steam flow integrator, a two-pen recorder for air temperature in and out of the air preheater, a CO_2 and steam flow recorder with indicator plate, a two-pen recorder for gas temperature in and out of the air preheater, and a push button station with indicating lamps for forced-draft fan, induced-draft fan and stoker. The drum controller

for the forced and induced draft fans will also be located behind this board and arranged with hand wheels mounted on the board.

Data of Principal Equipment at Piqua, Ohio, Municipal Plant

Boilers

Two, 4-drum, bent tube—heating surface, 6800 sq. ft.—design pressure, 400 lb. per sq. in.—capacity 60,000 lb. of steam per hr..... *Combustion Engineering Corporation.*

Superheaters

Two, Elesco convection type—1080 sq. ft. of surface, gas-touched—700 fahr. total steam temperature..... *The Superheater Company.*

Boiler accessories

Tube cleaners..... *Lagonda Manufacturing Company.*
Soot blowers..... *The Bayer Company.*
Water columns..... *Paul B. Huyette Company* (Reliance).
Steam pressure gage..... *Crosby Steam Gage & Valve Company.*
Safety valves..... *Consolidated Ashcroft Hancock Company.*
Blowoff valves..... *Yarnall-Waring Company.*
Miscellaneous boiler valves..... *Edward Valve & Mfg. Company.*

Waterwalls

Bare-tube type installed in furnace side walls—heating surface 280 sq. ft., including waterbacks..... *Combustion Engineering Corporation.*

Boiler and furnace tubes..... *Globe Steel Tubes Company.*

Air preheaters

Two, tubular—2164 sq. ft. each..... *Combustion Engineering Corporation.*

Stokers

Two, Green Chain Grate—effective surface 187 sq. ft.—each designed to burn 8500 lb. of coal per hr. at maximum rating ..... *Combustion Engineering Corporation.*

Forced draft fans

Two, each 23,400 c.f.m.—5 in. water.... *B. F. Sturtevant Company.*

Induced draft fans

Two, each 64,000 c.f.m.—3.5 in water... *B. F. Sturtevant Company.*

Arches..... *American Arch Company.*

Settings

Contractor..... *Ballard Sprague & Company.*
Brick and special tile for settings..... *General Refractories Company.*
Insulation for settings..... *Armstrong Cork & Insulation Company.*
Plastic insulation and refractory for settings..... *Refractory & Engineering Corporation.*

Electric motors..... *Allis-Chalmers Manufacturing Company.*

Motor controls.... *Cutler-Hammer, Inc.*

Boiler instrument panel..... *Combustion Engineering Corporation.*

Indicating and recording instruments

Steam pressure gage—steam flow and CO_2 recorder—steam temperature and pressure recorder—air temperature recorders—gas temperature recorders—multiple draft gage..... *Republic Flow Meters Company.*

Turbine-generators

Two, condensing type, 4000 kw., 5000 kva., 400 lb. per sq. in.—2300/4000 volt, 3600-r.p.m. generators—direct-connected, 125-volt exciters..... *Elliott Company.*

Condensers

Two, 6000 sq. ft., cast-iron shell surface, using $^7/_8$ in. × 16 ft. admiralty metal tubes—two-stage, double-unit air ejectors with I-A condenser..... *Worthington Pump & Machinery Corp.*

Crane

One, 30-ton, single-motor..... *Whiting Corporation.*

Boiler feed pumps

One, 125 g.p.m., 1100-ft. head, 4-stage, 3600 r.p.m. with multi-drive—one, same as above, with turbine drive..... *De Laval Steam Turbine Company.*

Condensate pumps

Two, 110-g.p.m., 1160-r.p.m., 2-stage, motor-driven..... *Worthington Pump & Machinery Corp.*

Circulating water pumps

Two, 6500 g.p.m., 870 r.p.m. single-stage, motor-driven..... *Worthington Pump & Machinery Corp.*

Coal and ash handling equipment

One, 15 ton per hr., 27 cu. ft. skip hoist, 240 cu. ft. truck hopper, 2600 cu. ft., overhead catenary coal bunker—2000 lb. larry with motor drive..... *Jeffrey Manufacturing Company* and *Fairbanks, Morse & Company* scale.
One, 1200 cu. ft., overhead catenary ash bunker, ash cars, trucks and arrangement for hoisting ashes on coal skip..... *Jeffrey Manufacturing Company.*
Two, 315 cu. ft., cast-iron plate with water collection gates. ..... *Allen-Sherman-Hoff Company.*
Two, Fairfield portable coal conveyers for yard storage.

Switchboard..... *Allis-Chalmers Manufacturing Company.*

Piping...... *Pittsburgh Piping & Equipment Company.* Special valves by *Edward Valve & Manufacturing Company, Schutte & Koerting Company,* and *Fisher Governor Company. Armstrong* traps. *Sharples* oil purifier, *Pittsburgh Piping & Equipment Company* crease bends, *Taylor* recording instruments, *American* thermometers and *Bailey* flow meters.

Extraction closed heaters

Two, 65 sq. ft., cast-iron shell, 6 ft. $11^1/_2$ in. × $^3/_4$ in. tubes. ..... *Cochrane Corporation.*

Deaerating heater

One, 55,000 lb. per hr., cast-iron shell, steel storage; arranged for doubling capacity in future..... *Cochrane Corporation.*

Zeolite water softener

One, 18 in., 60,000 grain unit.

Air compressor

One, 69 c.f.m., 100 lb., $7^1/_2$ × 6 single cylinder motor-driven unit. ..... *Worthington Pump & Machinery Corp.*

Revisions in Test Methods for Anthracite and Coke Approved by A.S.T.M.

The American Society for Testing Materials has just accepted for publication tentative revisions in the Standard Method of Test for Size of Anthracite (D310–31) and revisions in the Tentative Method of Sampling Coke for Analysis (D346–32T).

In regard to the revision of the Standard Method of Test for Anthracite, the committee originally accepted the names of coal sizes and the openings of testing screens as recommended by the Anthracite Operators Conference. This work now comes under the jurisdiction of the Anthracite Institute. As that Institute has revised the size of openings in the testing screens, the committee recommended that revisions be made in the standards to conform to the recommendations of the Anthracite Institute.

In regard to the revision of the Tentative Method of Sampling Coke for Analysis, a number of constructive criticisms were received after this method was published last year in tentative form by the Society. The revisions are believed to improve the original method of sampling in that (1) they more specifically call attention to the unreliability of surface sampling, (2) specify the number of increments to be collected, (3) allow for an increase in the unit for sampling in case of agreement between the seller and buyer and (4) give more specific directions for flattening the cone of coke.

A Method for Determining True pH Values

How many users of pH control know the exact pH value of the solutions they are testing? How many know that if two different indicators are used on the same sample, apparent pH values differing as much as 2 units may result with certain waters? The author describes a method of determining the true pH value of unbuffered water, such as condensate, which offers little resistance to change in pH.

By JAMES N. EVANS
Brooklyn Edison Company

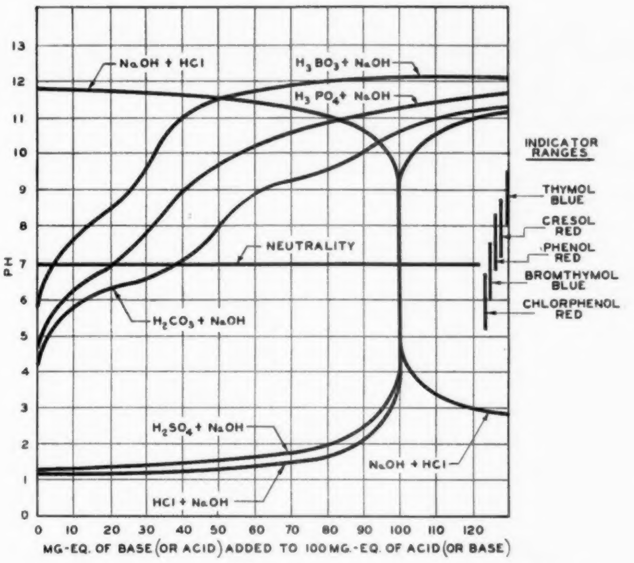
MANY articles have been written about pH—what it is, how to test for it, and what its many uses are in the industrial world. Briefly, the pH value of a solution is a measure of its acidity or alkalinity. The lower the pH value, the more acid the solution; and the higher the pH value, the more basic. The pH scale ranges from 0 to 14. Its values can be determined by electrical means, but are more often determined colorimetrically. Colorimetric testing has been found to be very simple and has been widely used with success for the control of the acidity or alkalinity of various industrial processes and for the prevention of corrosion.

In power plants pH testing has been found to give widely varying results on condensate and boiler feedwater due to the purity of these waters and the consequent effect of small amounts of impurities on the pH value. Such waters are termed "unbuffered" as contrasted to "buffered" solutions which resist changes in pH value by the addition of small amounts of impurities. This buffering effect is quite apparent from Fig. 1, taken from Edward G. Mahin's "Quantitative Analysis," which shows the changes of pH value in solutions containing various amounts of some of the common acids and bases. It will be noted on the curve of NaOH and HCl, between pH values of 4.5 and 9.5, that the addition of small amounts of either the acid or the base alters the pH value considerably. In this range the solution is said to be "unbuffered." On the other hand, the curves for phosphoric, boric and carbonic acid show that these solutions are more or less buffered throughout their entire range.

The unbuffered waters found in power plants can be tested colorimetrically with a fair degree of accuracy if certain precautions are taken to prevent contamination and if the results are analyzed properly. The indicators used are buffered to some extent so that when they are mixed with a sample of unbuffered water, the resulting mixture has a pH value which will not be the true pH of the water unless the pH of the indicator is the same as that of the water with which it was mixed. Thus, for example, if bromthymol blue with a pH value of 6.8 and thymol blue with a pH value of 8.8 are both used on the samples of the same water two different apparent pH values may result. This is shown graphically in Fig. 2, the areas representing apparent pH values obtained with the different indicators. From this chart it can be seen that in the lower ranges of each indicator the apparent pH values obtained are higher than the true pH value and likewise above the midpoint of each indicator the apparent values are less than the true pH value of the water tested. It is only at the midpoint of the indicator range that the true pH value is obtained.

Thus, if a sample of unbuffered water is tested with phenol red and an apparent pH value of 7.6 is obtained this can be accepted as the true pH value since it is the pH value of the indicator. If the same sample is tested with bromthymol blue, a value less than 7.6 and greater than 6.6 will be obtained. From the chart, values between 7.0 and 7.3 would be expected with bromthymol blue, but this chart applies only to solutions with a given small amount of buffering, and actual test work would be necessary to reproduce the chart for other waters. If a sample of water gives values above the midpoint of one indicator and below the midpoint of the next higher indicator it can safely be assumed that the true pH value of the water is between the two apparent pH values obtained with the two different indicators.

If a more accurate pH value is required it would be necessary to vary the pH value of the indicator until there is no change in pH value when mixed with a sample of water. This method, known as the Kolphoff method, is the ultimate where accuracy is desired. With some waters that the writer has tested even this method would not give absolute results however. One sample gave values of 7.1 with bromthymol blue, 7.6 with phenol red, 8.0 with cresol red and 8.4 with thymol blue. In this case midpoint pH values were obtained with the two middle indicators at 7.6 and 8.0, and with the other indicators the apparent pH values were 0.3 above the midpoint of the range of the lowest and 0.4 below the midpoint of the range of the highest indicator. Varying the pH values of the indicators between 7.6 and 8.0 probably would have given apparent values equal to those of the indicators used. Fortunately, such unbuffered waters are very rare.



(*Reproduced from "Quantitative Analysis" by Edward G. Mahin.*)

Fig. 1—Changes in pH with addition of common acids and bases

It is true that the indicator solutions are buffered to a certain extent but they must be checked constantly to be sure that the pH value has not been changed by contamination with any impurities. This can best be done by comparing the color of the solution with that of a sealed vial of the indicator. These sealed vials can be obtained on request, from the manufacturer of the indicator. The pH value of the indicator can be corrected to that of the standard by the cautious addition of dilute HCl or NaOH.

Caution Necessary against Contamination

It has been found that careless sampling and testing leads to large errors. Contamination of the sample with air, for example, causes errors as great as 1.0 pH unit. These and other errors can be avoided if the following precautions are observed.

The sampling bottles, pipettes and other pieces of equipment which are to come in contact with the sample should be chemically clean. Hard glass should be used in preference to soft glass because the solubility is less in pure water. Rubber stoppers should be used in preference to cork unless the cork is coated with paraffine as cork has a slightly acid reaction. Stoppers must never be laid on their side nor should the wetted portion be touched with the fingers. Sampling lines should be flushed out for several hours to make sure that they are chemically clean. The sampling line should be carried to the bottom of the flask or sampling bottle and the sample allowed to overflow for several minutes so that air contamination will be a minimum. Samples should be cooled to room temperature before they are allowed to come in contact with the air.

In testing the sample, it will be found that air contamination can be kept at a minimum by the use of a pipette instead of pouring. The sample to be tested should be drawn from well below the surface of the water in the container. This portion of the sample can then be transferred to a test tube in which a measured amount of the indicator has already been placed. The tip of the pipette should be held below the rising level in the test tube, and it will be found that the solutions are well mixed and require no shaking. The color of the resulting mixture should then be matched with the standard colors for the indicator used.

If the apparent pH value is above the midpoint of the indicator used, the test should be repeated as explained previously with other higher range indicators until one is found which shows an apparent pH value below or at its midpoint. If a sample shows an apparent pH value at the midpoint of one indicator this can be accepted as the true pH value. If, however, the apparent pH value is above the midpoint of one indicator and below that of the next higher indicator, the true pH value can be assumed to be close to the arithmetical average of the two apparent pH values.

Determination of True pH Curve

The "true" pH curve, as shown in Fig. 3, was developed in the following manner: Samples of condensate were taken from the discharge of condensate pumps in $2^1/_2$ liter bottles. This water was the purest water available, despite which it was found that samples pipetted from near the bottom of the bottle did not change in pH values for the first two hours at least. Small measured quantities of NaOH and HCl were added to the samples and the pH determined before and after each addition. Shaking the sample and thereby mixing air with the sample caused a change in the pH value of the water. This shaking effect was added to or subtracted from the changes caused by the addition of the acid or base, since it was necessary to shake the bottle to mix the acid or base with the water.

The milligram equivalent amounts of acid or base

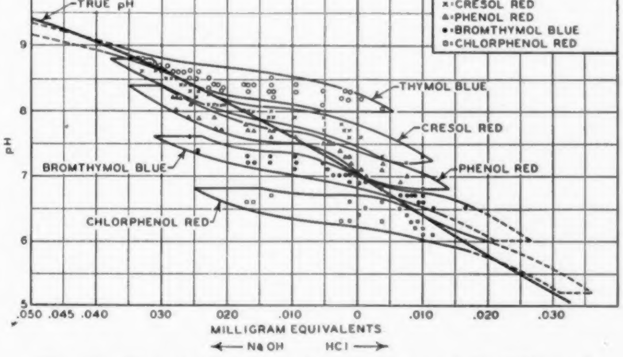


Fig. 2—Showing range of pH values with different indicators

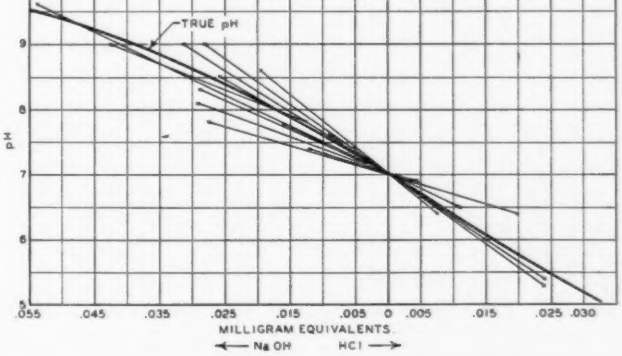


Fig. 3—Development of true pH curve

were calculated from their volumetric amounts and, for example, where the addition of 0.5 cc. of NaOH caused an apparent rise in the pH value of 1.0 pH and the shaking effect caused a decrease in the pH value of 0.6, it was assumed that the total effect of the NaOH alone was 1.6. Likewise using the same shaking effect, if it was found that the same equivalent amount of acid caused an apparent drop in pH of 2.2, it was assumed that the effect of the acid alone was 2.2 − 0.6 or 1.6. These values were then plotted in curve form in Fig. 3. Changes in pH value occasioned by the addition of a certain amount of acid or base were plotted as two points connected by a straight line for convenience, and the "true" pH curve plotted from these points. Theoretically the true pH value for this curve must pass through 7.03 when there is an equal equivalent amount of NaOH and HCl. The curve is in error to some extent because of the CO_2 present, since no efforts were made to exclude this gas. The amount of CO_2 absorption and the amount of error are not known, but it is felt that the curve as plotted is sufficiently accurate to serve as a basis for the indicator curves as given in Fig. 2. As mentioned before these indicator curves are true only for a water with a certain buffering effect, and any other water would give a different set of curves. The word "true" is used in quotation marks advisedly in certain cases above because no check methods were used to corroborate the basic theory.

Central Heating Plant for the Chicago Loop

A few days ago it was reported that the proposed central heating plant for the down-town section of Chicago is to use natural gas brought to the city through the recently completed 1000-mile line from Texas. Since the fuel consumption of this plant will be over 2,000,000 tons annually, the coal interests felt uneasy. S. W. Tracy, president of the Chicago Tunnel Co., which will build the steam plant, denied this and stated that no fuel other than coal has been considered. He also said that the plant is to contain eight 25,000 sq. ft. boilers and that distribution is to be through lines to be located in the existing freight tunnel owned and operated by the company. The company's plans are of a tentative nature pending the consummation of financial matters.

A few weeks ago Mr. Tracy was in Washington, together with other company officials, trying to arrange a loan, reported to be $10,000,000, from the Reconstruction Finance Corporation. Powerful outside interests are said to be opposing the project.

The Chicago Tunnel, a labyrinth of underground passageways, 62 miles long and 40 ft. below the street level, has made this engineering feat possible. At present the tunnel is used to deliver coal and other freight to the buildings in the Loop District. The plant will be located at the foot of Randolph St. just east of Michigan Ave., the site having been purchased for $700,000.

Michigan Ave. is Chicago's Fifth Ave. and some of the city's proudest skyscrapers are located here. However, the plans for the steam plant call for an edifice that will in no way be eclipsed by the surrounding architectural masterpieces.

Practically all the buildings in the area to be served have their own steam plants, the section is completely built and little or no new construction is expected in the near future. In order that the new plant may be able to provide steam cheaper than can be generated in the individual installations, its operating expense must be lower than the operating expense of the other plants to the extent of their fixed charges.

Opinion on Embrittlement Unchanged

During the last year I have received information from several sources that persistent rumors are being circulated to the effect that I have changed my opinion in regard to the cause of embrittlement in steam boilers and and the use of sulphate to prevent this difficulty. One of these rumors is to the effect that a large power plant operating at a steam pressure in the neighborhood of 400 lb. maintained the 3 to 1 sodium sulphate-to-total alkalinity ratio as recommended by the Boiler Code Committee of the American Society of Mechanical Engineers, and that embrittlement cracking took place. Another is to the effect that I have admitted that caustic is not one of the contributing causes of embrittlement.

It is extremely difficult to trace rumors to their source, and once a rumor is started, it spreads very rapidly. I have answered numerous inquiries in which men hearing these rumors have written to me directly. However, it becomes very difficult to stop these rumors by writing a few letters. I would like to make a public statement at this time to the effect that these rumors are not correct. I still believe that embrittlement in boiler plate is caused by the combined action of stress and chemical attack. The stresses are inherent in the construction and operation of the boiler, while the chemical attack is caused by the presence of sodium hydroxide in the boiler water. I also believe that the presence of sodium sulphate in the boiler water tends to retard the embrittling effect of the sodium hydroxide, and if in proper proportions, will stop it entirely. I hold this opinion due to the fact that no evidence has been presented to the contrary. If at any time such evidence is produced, I will be willing to investigate the evidence and make a public statement as to the results. I would appreciate it very much if you could publish this statement for me in your publication.

Frederick G. Straub
University of Illinois
Urbana, Ill.

Boiler Manufacturers' Code Approved

On October 3 the President approved the N.R.A. Code for boiler manufacturing and affiliated industries. It covers all steel power, stationary and marine boilers, except boilers for locomotives, steel heating boilers and vertical fire-box boilers. The American Boiler Manufacturers Association and Affiliated Industries has been designated as the co-ordinating agency. This association includes, in addition to boiler manufacturers, those making pulverized coal equipment, stokers above 30 sq. ft. and Class 1 welding.

Fusion Characteristics of Fractionated Coal Ashes

By Dr. A. H. MOODY, Chief Chemist
United Electric Light & Power Company
and
By D. D. LANGAN, Jr.
United Electric Light & Power Company

Certain portions of coal ash may become isolated in the boiler and exhibit different fusion temperatures than the average coal ash mixture. The authors describe a method which predicts whether a given coal is liable to have low fusing constituents not detectable by the standard A.S.T.M. method of determining fusibility and which may cause troublesome slagging or clinkering.

FUSIBILITY of coal ash as determined by the method prescribed by the American Society of Testing Materials[1] has long been used as a measure of the refractory qualities of the ash and as a guide to its clinkering properties and tendencies toward slag formation on boiler tubes. Unfortunately, the relationship is only approximate and there are frequent exceptions. E. B. Ricketts[2] mentions the fact that certain West Virginia coals may have considerably lower fusion temperature than Pennsylvania coals but still give less clinker trouble.

1. Given coal from the same bed, the clinker trouble usually increases as the fusion temperature decreases.
2. On coals from the same bed, clinker trouble usually increases with an increase in ash content.
3. On coals from different beds, the relation between ash fusion temperature and clinker trouble may vary through fairly wide limits.

Mr. Ricketts states further that he has seldom seen a coal from Pennsylvania with a fusion temperature below 2450 deg. fahr. which did not give serious clinker trouble. Few of the coals from West Vriginia have an ash fusion point above 2450 deg. and he has seen many of these coals with a fusion point between 2200 and 2300 deg. fahr. which gave little or no trouble with clinkers.

When attempts are made to correlate tube slagging with the laboratory determination the inconsistencies are more numerous than in the case of clinker trouble. Recent observations made on tube slag from a Springfield cross-drum boiler are a case in point. This boiler had been burning Pennsylvania coal with a fusion temperature of about 2700 deg. fahr. for a period of two months. The boiler was then taken off the line for repairs and cleaning. Samples of slag from water wall fin tubes were taken for observation and study. The inner portion of the slag, that adjacent to the tube, was not completely fused. It consisted of a honeycombed, sintered mass with spots of what appeared to be pure ferric oxide. The center section had a black glossy appearance, having been completely fused, because of the insulating properties of the inner slag. The outer layer was an unfused conglomerate of ash held mechanically by the molten matrix of the fused center portion. It is not at all improbable that some of the inner slag struck the tubes in the form of molten ferrous sulphide which has a melting point of 2185 deg. fahr. To this other ash particles could stick, and as the sulphide was oxidized to iron oxide, they would form a low melting agglomerate. This, of course, would not become liquid because of the cooling effect of the tube. The analyses of different sections of the slag are given in the following table:

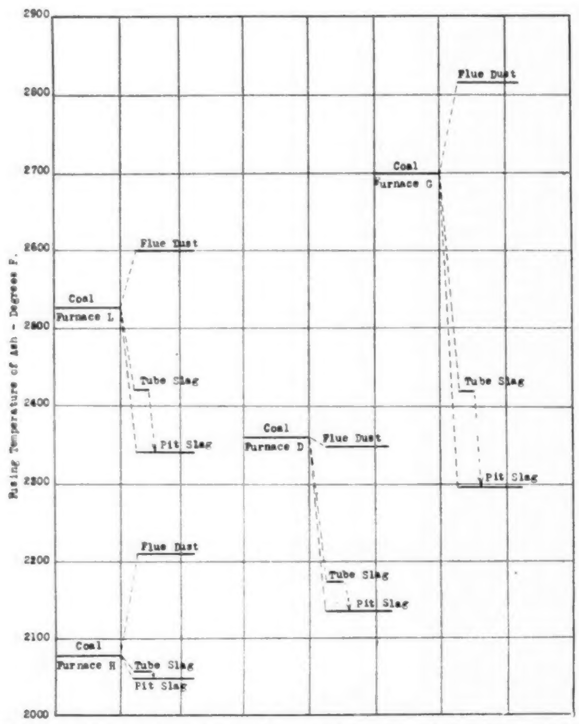
ANALYSIS OF SLAG SAMPLES REMOVED FROM SPRINGFIELD BOILER USING PENNSYLVANIA COAL

	Next to tube	Fused Center	Outer Section
		Per Cent	
SiO_2	41.7	45.3	51.5
Fe_2O_3	19.5	15.3	12.9
Al_2O_3	30.9	32.5	29.0
CaO	8.7	7.7	4.0
MgO	trace	trace	trace
Total	100.8	100.8	97.4
A.S.T.M. Initial Deformation temperature	2165 deg. fahr.	2200 deg. fahr.	2320 deg. fahr.
A.S.T.M. Softening temperature	2200 deg. fahr.	2230 deg. fahr.	2395 deg. fahr.

It should be noted that the slag nearest the tubes contains a high percentage of calcium and iron oxide, which give a sufficiently low initial deformation to enable the mass to stick to the cool tubes. It is reasonable to believe that if no such low fusing material had been separated from an ash having a composite fusion temperature of 2700 deg. fahr. there could be no accumulation of slag on the tubes.

Fig. 1, from a pamphlet by D. S. Jacobus and E. G. Bailey,[3] gives the fusion temperature of refuse collected at different points in the boiler setting as compared to the fusion temperature of the original coal ash. Flue dust in general gave a higher temperature than the coal ash while tube slag and pit slag were lower. These results show that certain portions of the coal ash may become isolated in the boiler and exhibit much lower or

[1] A.S.T.M. Standards 1924. D 22-24, p. 994.
[2] W. A. Selvig, et al., "Fusibility of Coal Ash as Related to Clinker Formation," Bulletin 29. Carnegie Institute of Technology, 1926.
[3] D. S. Jacobus and E. G. Bailey, "Removal of Ash and Loss of Carbon from Boiler Furnaces," Proceedings Second International Conference on Bituminous Coal, Nov. 1928.



(Taken from "Removal of Ash from Furnaces," by D. S. Jacobus and E. G. Bailey.)

Fig. 1—Fusing temperature of refuse collected at different points in settling compared to the fusing temperature of the coal ash

much higher fusion temperatures than the average coal ash mixture.

It is reasonable to suppose that a prominent factor in this phenomenon is the air separation of lighter and smaller particles in accordance with Stoke's Law. With some coals such a separation will isolate high or low fusing mixtures, depending upon the size and density of the coal ash constituents. Coal ash may be considered as being derived from two sources; the one ash is that which is inherent in the coal itself, the other is due to extraneous impurities. The former would be a very finely divided dust in texture; while the latter may include one or more of several forms; iron pyrites, shale, small seams of fine sand, shells or bones, silicate rocks and other impurities which may get into the coal during mining or shipping. The extraneous ash is usually lumpy or laminated in structure. In either event it is left in larger particles than the inherent ash when the coal is burned.

The controlling fluxes in coal ash are calcium oxide and iron oxides. If the extraneous ash is particularly rich in either or both of these fluxes, the refuse which is left on the tail of the stoker will have a lower fusion point than the representative coal sample. On the other hand, some ashes have most of the fluxes evenly distributed through the inherent ash, which would probably be the case when the inherent ash has a tan or brown color rather than a reddish gray. In the former the iron may be in the form of iron silicates and consequently cannot be isolated.

If laboratory tests are to indicate what might be expected in practice, the conditions to which the sample is submitted in testing should involve as nearly as possible the same principles. We know that in the boiler there is a separation of certain parts of the ash from other parts but the present standard method of determining the fusion temperature of ash takes no account of it. Application of these principles to laboratory tests was attempted in the following experiments.

Wet Method of Fractionation of Coal Ash

Representative samples of Pennsylvania coal and of West Virginia coal were crushed to pass a quarter-inch screen, and burned in an electric muffle furnace. A twenty-gram sample of the ash was then mixed with one hundred cubic centimeters of methyl alcohol. Methyl alcohol is used in this separation because its low density

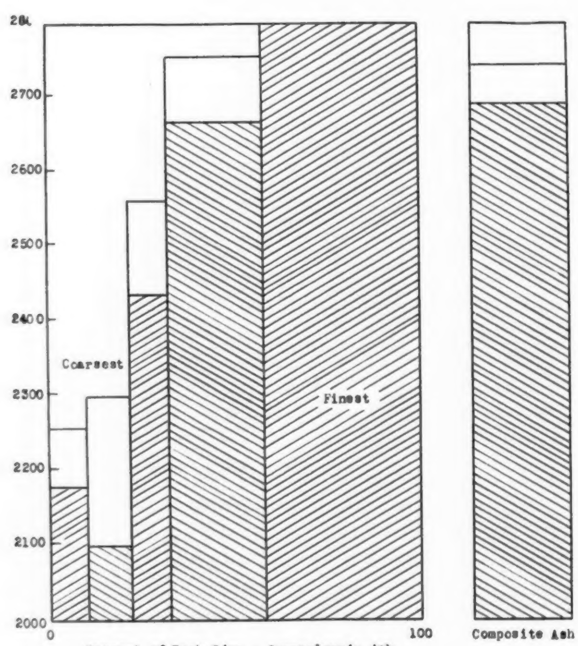


Fig. 2—Initial deformation and softening temperatures represented by cross-hatched and white sections, respectively, of fractions of Pennsylvania ash separated by alcohol sedimentation

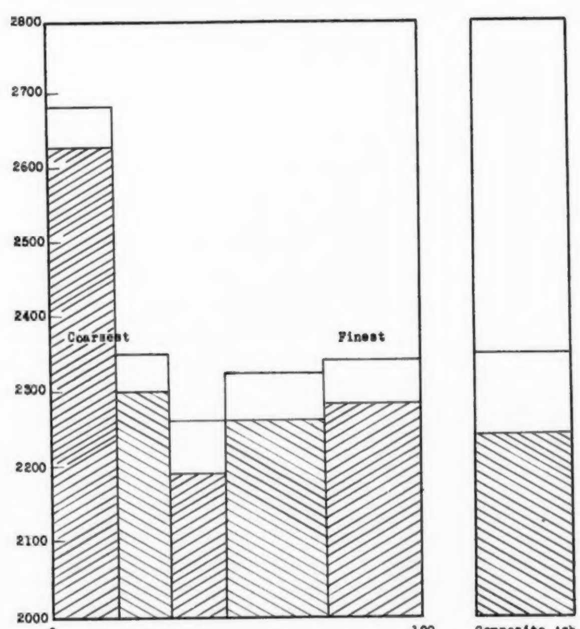


Fig. 3—Initial deformation and softening temperatures represented, respectively, by cross-hatched and white sections of fractions of West Virginia ash separated by alcohol sedimentation

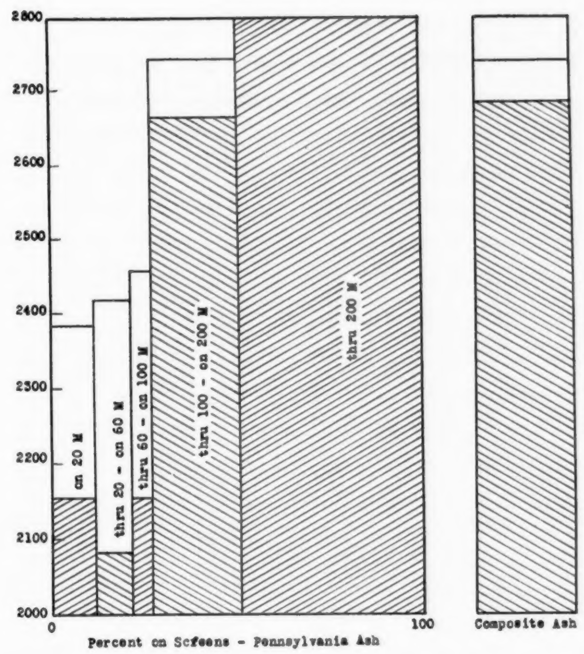


Fig. 4—Initial deformation and softening temperatures represented, respectively, by cross-hatched and white sections of fractions of Pennsylvania ash separated by screening

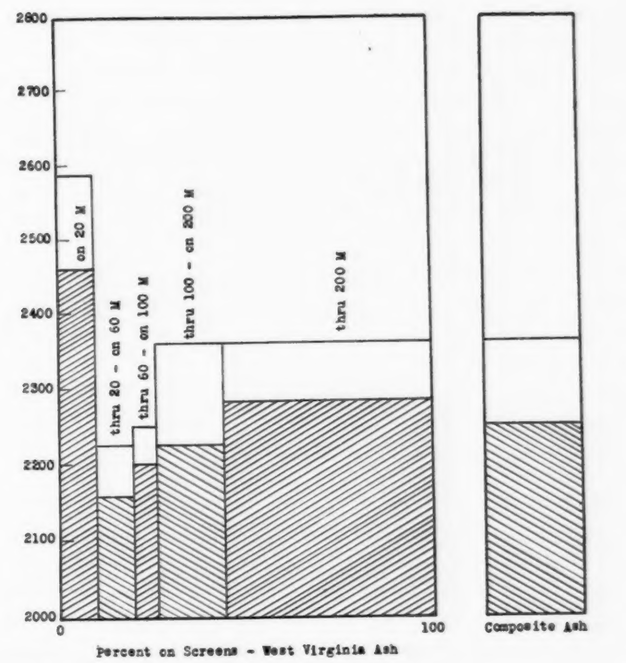


Fig. 5—Initial deformation and softening temperatures represented, respectively, by cross-hatched and white sections of fractions of West Virginia ash separated by screening.

and viscosity facilitate rapid settling, and because the active fluxes, sodium and potassium carbonates are not soluble in it. A four-foot length of one-inch glass tubing, suitably supported in a vertical position, with the lower end held firmly against several layers of filter paper laid on a large rubber stopper, was filled to within ten inches of the top with methyl alcohol. The mixture of ash and alcohol was poured quickly into the tube through a large funnel, and the ash allowed to settle until clear. The clear liquid was then siphoned off. A stream of air was kept on the filter paper to evaporate the alcohol which seeped through. When the ash was almost dry, the tube was placed in a horizontal position and the ash cake forced out by pushing a rubber stopper through the tube. The ash was then sliced into five parts, in such a way as to have each contain as nearly as possible particles of a uniform size. When dried each section was weighed and its percentage calculated. Fusion tests were made on each fraction by the A.S.T.M. method.

Dry Method of Fractionation of Coal Ash

Five fractions of ash were separated from duplicate samples of both West Virginia and Pennsylvania ashes by screening. A twenty-gram sample of ash was put in the top of a nest of Tyler standard screens of 20-mesh, 60-mesh, 100-mesh and 200-mesh sizes and placed in a mechanical shaking machine for fifteen minutes. The fusibility of each fraction was determined as in the wet method.

The fusion temperatures of the separated samples from both methods as determined by the A.S.T.M. standard gas furnace method are shown in Figs. 2, 3, 4 and 5. The upper limit of the cross-hatched section gives the initial deformation point, while the open section represents the fusing range of the cone, the top of which represents the softening temperature. Horizontal distances measure the per cent of the fractions separated. The coarse material is on the left and graduates to the fine on the right. To the right of each individual chart there is a representation of the fusion temperature of original coal ash by the A.S.T.M. method.

A comparison of the results obtained by screening with those obtained by alcoholic sedimentation shows that either of the methods will indicate the general characteristics of a particular coal ash. This simply means that in applying Stoke's Law the influence of the difference in size of the particles overshadows the difference in their density. In view of the close agreement of the results of the two methods it is the writer's belief that in testing any coal ash, a test on the screened sizes would give as good an indication of the characteristics of the ash as a perfect application of Stoke's Law. The screening requires only a few minutes while the sedimentation requires at least a full day. With coals of the foregoing type the test might be further shortened by using only three fractions, i.e., the coarsest twenty-five per cent, the second coarsest twenty-five per cent, and fines fifty per cent. The initial deformation and softening temperatures of these would give more accurate information concerning the nature of the ash, not shown by the present A.S.T.M. method as applied to an average ash sample. The screen test outlined above can be made on a small sample of coal in the laboratory, and it is believed that it would give results which would predict whether a particular type of coal would have a sufficient quantity of non-refractory impurities in it to form nuclei for troublesome slag agglomerates.

The Beaumont Birch Company announces the appointment of the Ernest E. Lee Company, 115 S. Dearborn St., Chicago, as their representatives of the Chicago territory, covering the sale of coal, coke and ash handling equipment for power plants and gas works.

Patents*

By GEORGE RAMSEY, New York
Patent Lawyer-Member A.S.M.E.

PART XII

Interference Procedure (Continued)

This and the two preceding instalments (see COMBUSTION, May and September, 1933) are devoted to the somewhat involved subject of interference procedure. Mr. Ramsey's present discussion takes up in detail the effect of termination without contest, motion to dissolve, denying patentability of the count, proving dates of invention, preparation of motion to dissolve, motions to amend an application, and interlocutory appeals. Where interference is to be fought it is important to properly contest all the intermediate steps such as the author has described.

Effect of Termination without Contest

WHERE a written concession of priority is made, it is a statement against interest and binds the inventor who makes it to the statement of fact that his opponent is the first and original inventor. Such a statement will usually result in his opponent obtaining a patent with broad dominating claims. Concessions of priority are usually the result of an agreement between the parties and, as has been previously stated, the common form of such agreement is a license arrangement between the parties which is satisfactory to both sides.

A written disclaimer has the effect of a broad concession of priority in that it is not directed in favor of any party, but it is merely to the effect that the party making the disclaimer did not originate the invention defined by the counts of the interference. This also has the effect of an estoppel against the party making it so that he may not again assert inventorship to that which he has disclaimed.

A written abandonment is in effect an assertion of right to the invention but the inventor for some good reason decides that he will give up his rights in the invention. This does not permit some later inventor to pick up those rights except under special circumstances. Where a complete application is abandoned and no divisions or continuations are filed, no patent will issue that will disclose in its specification the abandoned invention.

Abandoned applications stand substantially as abandoned experiments and do not bar a subsequent application to some other original inventor. In this case "original" inventor means one who makes his invention without knowledge of the subject matter of the abandoned application. Of course, if there is a publication of the subject-matter of the abandoned invention, then the publication may be effective as a reference against a subsequent inventor but, so far as the abandoned application itself is concerned, it does not stand as a reference. The relationship of the parties in an interference, however, may constitute an exception to this rule in that if an interference is proceeding and the junior party is unable to overcome the senior party's filing date, the abandonment of the senior party's application will not change this fact and the Patent Office will continue to refuse the claim to the junior party on the ground that he is not the first inventor. Even if the senior party wished to concede inventorship to the junior party, the Patent Office would not permit it where the preliminary statement of the junior party asserted a conception date later than the filing of the senior party's application.

A concession of priority is in a sense a statement of fact, namely, the junior party states as a fact (or as an admission) that the senior party is the first inventor, and the Patent Office acts upon this evidence. It would be illogical for the Patent Office to act upon statements of the parties which are contrary to the records in the Patent Office. Therefore, if a junior party did not conceive the invention until after the senior party's filing date, the Patent Office would not permit the senior party to concede priority of invention to the junior party. Ordinarily, such a circumstance would not arise, but it sometimes happens that concessions of priority are made as a matter of convenience.

Where a party has actually completed an invention in a full sized operative machine, this also stands as a fact and if the completion of such machine is before the date of conception of another party, and the party who built the machine for some reason concedes priority to the junior party, such concession, of course, does not change the true facts. These facts may be developed as testimony by some third party who has been sued upon the patent carrying the broad claim of the interference and if the third party can show that the party who conceded priority was in truth and in fact the first inventor, the patent to the second party will fail.

A written concession, disclaimer or abandonment must be made by the inventor (his administrator or legal representative) and where there is an assignment of record, the assignee must also give written consent.

Motion to Dissolve

Another way of getting loose from an interference is by a motion to dissolve.

In an interference proceeding, the party who stands a good chance to win the interference usually wants the interference continued because, if he wins the interference,

he will get a patent which will dominate at least his opponent and perhaps others in the art. The chances of a party to win or lose an interference may be fairly well predicted when the preliminary statements are opened. Of course, the conclusions reached in each case must be based on the facts in that case, and the facts are different with every case. Where the junior party alleges a date of conception which is subsequent to the filing date of the senior party's application, it is an easy matter to prophesy that the senior party will win the interference, providing that his disclosure is operative and that his disclosure supports the counts. In such a case, the junior party has a bear by the tail and he cannot let go. The first thing under these conditions which the junior party will usually do is to try to find a basis for a motion to dissolve.

Motions to dissolve should be filed within a time period fixed by the examiner of interferences after the preliminary statements are approved. This period must not be less than thirty days. Ordinarily, the Patent Office will not enlarge this time except if the parties to the interference may agree that the time be extended. When such an agreement (usually called a stipulation) is filed in the Patent Office, the Examiner of Interference will usually reset the dates to conform to the stipulation. If an agreement cannot be reached with an opponent and more time is needed, it is advisable to file a statement in the Patent Office to the effect that more time is needed and that the motion to dissolve will be filed as soon as it can be prepared. Then when the motion to dissolve is filed, it should be accompanied by an affidavit or affidavits fully setting forth the reasons for the delay, and the affidavits should also state that an effort was made to obtain an agreement for more time from the opponent, but no agreement could be reached. The reason why the Patent Office will not extend the time, even if the showing is made for necessity of delay, is because the Patent Office takes the position the applicant should file the motion to dissolve as quickly as possible, and then at that time give the reasons for delay. These reasons are just as good at that time as they would be if they were stated earlier in a request for extension of time.

Where the motion to dissolve is in proper form and is filed within the fixed time, or where satisfactory reasons are given for delay, the examiner of interferences will notify all parties of a day set for argument on the motion before him. The parties may attend in person and file typewritten briefs. Copies of the brief must be supplied all opponents, but the brief need not be filed nor copies be given out until the party starts his argument at the hearing. The moving party is heard first, and where both parties have filed motions to dissolve, then the junior party is heard first. Briefs may be filed without any personal attendance. It is advisable, however, to have an attorney attend all hearings, because unforeseen points may arise at the hearing and the only opportunity to answer such points is to have competent counsel on the job.

If the motion is not in proper form, or if it is based on some allegation not permitted by the rules, the moving party will be notified of the defect and will be informed that so far as the defective part of the motion is concerned no hearing will be set. Such defect may go to the whole motion or only to a portion thereof, so that a motion will be set for hearing in part and refused in part, or refused as a whole. Where it is possible to amend or refile the defective part, opportunity will usually be given to correct the error and usually the period is set within which to respond and correct the defect.

The first ground based on "informality in declaring the interference" has to do more especially with the wording of the claim comprising the count of the interference, in that when the elements of the claim are applied to the disclosure of one application, they mean one thing, and when as applied to the disclosure of the other application, they mean something else, even though as a matter of language the claim may be read on either application. Under these conditions, the elements of the claim comprising the count in issue are stated in language so indefinite that the claim cannot properly be interpreted. This ground for dissolution may also cover the right of the party who brings the motion to make the claim, that is, he may contend that his own application does not disclose all of the elements of the count of the interference and that, therefore, the interference should not have been declared. This ground was one time known as "no interference in fact," which comes pretty close to being an accurate definition. It is unusual for an interference to be finally dissolved and terminated under this ground. What usually happens is that the interference will be re-formed on redrafted claims suggested either by the senior party or by the Patent Office and then the junior party will be tied tighter than ever to the conflict. Therefore, it is usually unwise to stand on this ground alone as a basis of a motion to dissolve. It is far better to include this ground with one of the other grounds.

Denying Patentability of Count

The second ground, namely, denying the "patentability" of the count in issue, is usually the favorite ground for motions to dissolve. The counts of an interference are to be read with the broadest normal interpretation of the terms used in the claims. If a normal reading of a claim covers the disclosure in some prior patent or publication which is a statutory bar, then the claim is unpatentable and the interference will be dissolved. If the differences between the prior art references and the claim is a mere matter of equivalents, then the interference should be dissolved on the ground of "no invention" in view of the prior art.

Where a United States prior art patent issues after the filing of an application in interference, but the patent is based on an application having a filing date which is earlier than the earliest alleged date of conception of any of the parties, such a patent is recognized as being a reference because it shows the parties in interference as not being the first inventors. If such a patent does not ante-date the earliest date of conception alleged in a preliminary statement of one of the parties, then such a patent is not a reference against such party. The preliminary statement of the party being under oath is accepted as an affidavit swearing back of such a patent. Such a patent will therefore be thrown out as a reference if the dates in a preliminary statement ante-date its filing date.

Dates of Invention Must Be Proved

The Patent Office expects the parties to prove their dates of invention by testimony. Where the interference terminates without testimony, the winning party may

later be required to file an affidavit setting forth full and complete facts to overcome the date of such a patent. When it comes to considering foreign patents as references, there are two dates which may be considered, one of which is the date when the foreign patent issues and the other is the date when the foreign patent is published, and the earlier date is the effective date. In some foreign countries, the publication of a patent specification takes place before the actual grant of the patent. This is particularly true with reference to England. It occasionally happens with reference to English patents that the specification and drawings will be published and for lack of a payment of a final fee, or for some other reason, the patent may never be sealed, that is, it never actually issues as a patent. Nevertheless, under these conditions such a British patent is available to the public as a publication and if, as a publication, it gets into this country before the earliest date of conception of any party to the interference, then it becomes a reference against the patentability of the count in interference.

It is not unusual for a reference to apply against only one party to an interference and not to the other. The law makes a publication, which ante-dates an application date by two years or more, a statutory bar to any patent on the said application. It is not unusual for the effective date of such a publication to come between a junior and senior party.

This second ground, namely, patentability, is not available in all cases. The present Patent Office rules (for no good reason) deny the right of a junior party, who has not alleged conception as early as the senior party's filing date, to question the patentability of any count in interference. This rule is based on the proposition that a junior party who could not possibly win the interference should not be permitted to argue that the count is unpatentable. The junior party is, however, permitted to argue that the interference is informal and that his opponent has no right to make the claim since these grounds do not attack his own right to a patent. He may win out on either grounds one or three and may get a patent because of the fact that the senior party has no right to make the claim. That is, it occasionally happens that an interference is started when as a matter of fact it should not have been declared because when the count of the interference is analyzed it may be found that the senior party does not disclose the invention called for by the count. Under these conditions, the junior party would be entitled to win out even though he did not make the invention until after the senior filed.

This rule forbidding the junior party to attack patentability of the count, however, seems wrong because the public always has an interest in the issuance of a patent, and if the junior party who has not overcome the senior party's filing date can show to the Patent Office a complete anticipation for the count, he should be permitted to present his case on a motion to dissolve the interference.

The rules do provide a sort of palliative in that a junior party who cannot overcome the date of the senior party may file a statement as to his reasons for considering the counts in interference to be unpatentable. This statement is referred to the primary examiner after the termination of the interference, and will be considered by the primary examiner before the application of the senior party is passed to issue.

Preparation of Motion to Dissolve

A motion to dissolve based on lack of patentability of the counts should be very carefully prepared and presented. The reason for extreme care and a full presentation being that the moving party never gets but one chance to argue that the count is not patentable. The Rules prohibit appeals from a decision on a motion to dissolve which decision holds the counts patentable. If his motion is denied, this question of unpatentability can never be raised again in the interference as to the same references. Of course, if later some new and complete reference is found, the Patent Office may consider it, but the question of patentability of the count in view of a specific reference can be raised but once.

The third ground for motion to dissolve is an extremely important one, namely, the "right of an opponent to make the claims" of the interference. In other words this ground is an assertion that there is no proper foundation in the opponent's case on which to base the claims in interference. This ground of a motion to dissolve may be based on operativeness of an opponent's application or it may be based upon the interpretation of the terminology of the counts of the interference as to the disclosure in the opponent's application. The reason why this ground of a motion to dissolve is so important is that the points raised under this ground of "right to make the claim" may all be carried up on final appeals. Not only that, but it may be the basis of a junior party, hopelessly lost as to date of priority, to win out. Right to make a claim has nothing to do with dates. It deals with substance. If the application which is attacked will not as a matter of substance support the claims of the interference then it matters not how early the application was filed. On this point, it is the disclosure of the application as originally filed that counts. If some foundation for the counts has been injected by amendment, and it was not caught by the Examiner as "new matter," the moving party should raise this point as a basis for the attack of no right to make the claims.

Occasionally, a motion to dissolve will be based upon inoperativeness of the disclosure of an application and this disclosure may be so complicated a mechanism as to require demonstration, for example, the question of inoperativeness may relate to a complicated calculating machine. The demonstration may require building the models. Then the question arises as to whether these models are in accordance with the disclosure of the application whose operativeness is attacked. All of this can be established by expert testimony. Therefore, under these conditions, a motion to dissolve is filed and a petition is filed asking for leave to take depositions of experts in the art. Under these conditions, if leave to take testimony is granted, the full consideration of the motion to dissolve is usually postponed until final hearing, at which time the testimony of experts and the question of operativeness will be considered. If leave to take expert testimony is denied, then the models may be used to demonstrate the argument and it is up to the Patent Office to determine if the models are accurate.

A motion to dissolve must set forth sufficient statements of fact to make it clear to an opponent exactly what is being relied upon as the ground for dissolving the interference. A motion which does not do this will not be set for hearing. Usually, however, the moving party will be given opportunity to amplify his motion.

A motion to dissolve is a very important step in an interference procedure and should be very carefully considered. It may be far reaching in its effects and on its consideration may rest the entire future proceedings of the interference. When a motion to dissolve is set for hearing all further proceedings in the interference are suspended until after the decision on the motion to dissolve.

It occasionally happens that both parties to the interference will agree that the interference should be dissolved, or in other words, will agree that the interference should never have been started in the first place. When this happens usually no hearing date is set, but the Examiner of Interferences will dissolve the interference and thus the interference is terminated. If such a motion is based upon patentability of the count, the agreement of the parties amounts to a disclaimer by both parties that the common subject-matter between the parties is not patentable. Neither party will get the claim of the interference and each party will get a patent on his specific disclosure, which patent will be of such narrow scope as not to read upon his opponent. Therefore, the Gordian knot between the applicants is severed and each goes his respective way without dominating the other.

An Unusual Case

An interesting case is one where a junior party filed shortly after the senior party. The senior party never built his device, but the junior party had built his machine before the date of conception by the senior party. The count of the interference came from the senior party's application and was specific to a feature not disclosed by the junior party who, however, had broader claims in his case. Neither party wanted to go to the expense of taking testimony. The senior party brought a motion to dissolve based on the ground the claim in issue was specific and that the junior party did not disclose the specific invention in issue, and, therefore, that the junior party had no right to make the count of the interference. The junior party stated on the record of the case that he agreed with the motion of the senior party, and that the motion should be granted. The Examiner of Interferences dissolved the interference. Both applications went back to the Primary Examiner who promptly allowed the senior party's application which soon became a patent. Then the Examiner rejected the junior party's broad claims on this patent because it was filed before the junior's application. The junior submitted an affidavit setting forth proof of the fact that the junior party actually built the machine of his disclosure before his opponent had conceived his specific invention. This untangled the snarl which the Patent Office should not have started in the first place because an interference which is dissolved on facts of record should never have been declared. The Patent Office then allowed the junior party's application with broad claims that covered the senior party. This case has been referred to in detail because it is a bit unusual.

Where an interference is declared between a patent and an applicant, the counts of the interference must be claims of the patent. Consequently, the Patent Office has adjudged the claims to be patentable and if the applicant brings a motion to dissolve on the ground that the claims are not patentable, the Patent Office immediately dissolves the interference without any hearing. The Patent Office takes the position that if the applicant wishes to say the claims are not patentable, there is no need for further contest, since the patentee already has the claims. This automatically terminates the interference and leaves the patentee with his patent. Ordinarily, a patentee will not be heard to argue that the counts comprising the claim of his patent are unpatentable. It seems reasonable, however, to permit a patentee to bring such a motion based upon newly discovered prior art, providing that the patentee shall promptly file a re-issue application or shall offer to file a disclaimer in case the motion is granted.

The patentee may very properly bring a motion to dissolve on the grounds of informality in declaring the interference and that his opponent has no right to make the claims. He cannot, however, place a strained and unusual interpretation on his claims in order to say these claims do not read on his opponent. He may argue that the claims define elements not disclosed by his opponent or any other proper ground as to why his opponent cannot make the claims.

The mere fact that a patent is in interference in the Patent Office will not tie up the patent to prevent the patentee bringing suits for infringement even against the same party with whom he is in interference. An interesting case was one when a suit for infringement of a patent was brought and the defendant promptly copied the claims of the patent in an old pending application and asked for an interference, which was declared. The patentee stopped the interference by a public use proceeding (which will be explained hereinafter). Now when the defendant came to trial he tried to say his device did not infringe, in other words, he argued that the claims did not read on his structure. The Court refused to hear this defense of non-infringement because the defendant had copied the patent claims into an application disclosing the identical device in suit. His action in copying the claims was an assertion, in fact a very forcible assertion, that the claims did cover his device. His own action established the fact that he infringed, if the patent was valid, and unfortunately he blocked the principal avenue of escape. He lost the case.

Motion to Amend

During the motion period, after the parties have seen each other's applications, the party who feels that he is likely to win out in the interference or who feels that he may not win on a count as set forth in the declaration but that he can win on a claim to other common patentable subject-matter, usually brings a "Motion to Amend" his application by adding claims which, in his opinion, should comprise interference counts between himself and any one of the other parties. It has been previously pointed out that during an interference the prosecution and amending of an application is suspended. An interference proceeding, however, is considered in the law as settling all points of invention common to the parties involved. Consequently, if there is some other common subject-matter, which is not involved in the count of the interference, the parties should ask to have this common subject-matter placed in interference so that one contest will clear up the entire case, and the procedure to do this is to bring a motion to amend. This motion to amend should be brought within the motion period. However, it sometimes happens that common patentable subject-matter will not be brought to light

until after a motion to dissolve has been filed. It may appear that the motion to dissolve completely disposes of the counts in interference, but that even after these counts are disposed of, there is still patentable subject-matter common to the interfering applications. The Patent Office procedure, therefore, provides that a motion to amend may be filed within the motion period or within thirty days after a motion to dissolve by another party has been filed.

The procedure on filing a motion to amend is to submit the new claims by motion and to point out specifically how the claims read on the disclosure of the several applicants, and also if there has been a motion to dissolve to point out how the claims are patentable in view of any art which has been raised on a motion to dissolve. These claims may be claims already in the application of one of the parties or they may be claims which are entirely new as to all the applicants. This motion should also be accompanied by a proposed amendment to the application of the moving party (provided he is making new claims or is taking claims from one of his opponents), which amendment proposes to add claims in his application identical with the claims which are suggested as additional counts to the interference.

Where a corporation, or an individual, owns a number of applications by different inventors and one of the inventors gets into interference, the corporation may find that the application of its opponent discloses inventions involved in applications by other inventors which it owns. In this case, the common assignee is entitled to suggest that additional interferences be declared with applications of the said other inventors. This procedure is also by way of a motion to amend. In this case, one of the parties to the interference moves to amend the interference by the addition of counts comprising claims from one of the other applications which the moving party owns. Where this procedure is taken, the applications which are moved to be included are laid open by the Patent Office to inspection to all opponents. This enables the opponents to be prepared to present any argument they may wish to make as to why the interference should not be amended. The arguments in opposition to a motion to amend are based on the same grounds as arguments in support of a motion to dissolve.

When a motion to amend is filed in proper form, it is set for hearing before the examiner of interferences. If motions to dissolve have been filed, all motions are usually set for hearing on the same day before the same tribunal.

Where a party intends to oppose a motion to amend on the ground that the claims suggested are not patentable in view of prior patents or publications, notice of the patents or publications to be relied upon must be given to the opponents at least five days prior to the date of the hearing. Then, when the hearing is granted, these prior patents or publications may be analyzed to show that the proposed counts are not patentable.

If the motion to amend is granted, all parties are required to make the new claims in their applications and the interference will be re-declared or a group of new interferences will be declared, wherein certain parties will be involved in one interference and other parties will be involved in another interference. New preliminary statements will be required as to the added claims. If the added claims set up a new status, motions to shift may be in order. Motions to dissolve cannot be brought as to the new claims because any ground for a motion to dissolve could have been presented in opposition to the motion to amend at the time when the motion to amend was heard before the examiner of interferences.

Where an application and a patent are in interference, a motion to amend is not in order except to place in interference claims of the patent other than those chosen originally for the declaration of interference. Where a patentee wishes to contest an interference on claims other than those of the patent, he may file a reissue of his patent and add in the reissue the claims which he wishes to contest in the interference. The Patent Office cannot compel a patentee to reissue, so occasionally a rare situation arises where a patentee has some immaterial limitation in his claims that the applicant does not disclose and yet there is in fact interfering subject-matter. In this case, the Patent Office may ignore the limitation and declare the interference on a claim without the immaterial limitation. Such an interference will proceed the same as if the limitation did not exist.

Interlocutory Appeals

Where a motion to dissolve is granted on any of the grounds specified or where a motion to amend is denied on any of the grounds specified, an appeal may be taken to the Board of Appeals. An appeal at this time and from these motions is known as "an interlocutory appeal." This means that it is an appeal before the final decision is made and that it relates to some question other than the ultimate question which is the point to be finally decided. Where a motion to dissolve is denied or a motion to amend is allowed, no interlocutory appeal is permitted. The case must go on to final hearing and then certain of the interlocutory points may be raised at final hearing and an appeal may be taken to the Board of Appeals from the final decision. For example, where it is argued on a motion to dissolve that an opponent has no right to make the claim, and the motion to dissolve is denied, or where a motion to amend is granted over an objection to the right of the party bringing the motion to make the proposed claim, these points may be raised on final appeal from the decision of the examiner of interferences.

In view of this fact, it will be seen that where an interference is to be fought on all its grounds, it is extremely important to properly contest all of the intermediate steps.

Gordon Fox, who has been associated with the Leningrad staff of Freyn Engineering Company, has returned to the United States, and will resume his connection with the American activities of this company. Mr. Fox has devoted the last five years to engineering work in the Soviet Union for Freyn Engineering Company, during which time this company, in association with the Russian organization, Gipromez, has supervised the development of the steel industry of the Soviet Union, and has directed the design of blast furnaces, open hearth and bessemer works, rolling mills and associated departments for all the major plants of this nation. Mr. Fox was identified with the power and electrical phases of this work.

Electric Steam Boilers*

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and

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While the number of electric-steam boiler installations in the United States is small, there are many factors at the present time which make desirable their consideration as a source of revenue for hydro-electric utilities. In general, hydro-electric operating companies find themselves during this period of business conditions with excess generating capacity, thus making available large amounts of energy at very little additional operating expense. The use of this excess capacity for the electrical generation of heating and process steam offers in some instances an opportunity for a substantial revenue. This is particularly true if the steam load is of a nature which permits it to be supplied by electric boilers either wholly or in part during the flood season. The two principal types are described and operating experiences given.

HYDRO-ELECTRIC utilities generally use large quantities of steam for such purposes as heating office buildings, substations, shops, warehouses, car barns and garages. In addition, they frequently supply steam to central heating systems. The generation of all or part of this steam by means of electric boilers will in many cases save a large item of expense for fuel and may prove to be economically desirable. This use of excess electrical capacity for generating steam may be considered as temporary, to continue only during this period of reduced load, in which case the depreciation of the equipment must be taken at a rather high figure. However, if excess transformer capacity is available temporarily from lightly loaded generating stations or substations, the capital investment required for the electric boiler installation will be very small and therefore the high rate of depreciation will not result in prohibitive fixed charges.

The operating cost of electric boilers is less than that of fuel-fired boilers because of the elimination of coal and ash handling, furnace repairs, tube cleaning and other items which are not required for electric boiler operation. Under certain conditions electric boilers can be made entirely automatic, thus further decreasing the operating cost.

The value of electrical energy for generating steam will vary within wide limits depending on the cost of fuel and on other factors characteristic to each installation. Assume for example a heating or process steam plant in which the load has increased to a point where new boilers are necessary. If fuel-fired boilers are installed the total cost of producing steam will be the sum of the fixed charges, operating cost and fuel cost. In the event of the installation of electric boilers, instead of fuel-fired boilers, the value of the electrical energy so used would be the difference between the above cost and the sum of the fixed and operating cost of the electric boilers. Since both the first cost and operating cost of an electric boiler are less than those of a fuel-fired boiler of the same rating, the value of the electrical energy used to produce a given quantity of steam will be somewhat more than the cost of fuel to produce the same quantity of steam.

However, electric boilers may be installed in a plant already possessing sufficient steam generating capacity and still provide a desirable source of revenue. In this case, the fuel-fired boilers being already installed, all the fixed charges except the depreciation caused by actual operation go on whether the equipment is used or not. The value of the electrical energy used under these circumstances is the difference between the operating and fuel cost of the fuel-fired boilers and the fixed and operating costs of the equivalent capacity of electric boilers, plus the reduction in the depreciation of the fuel-fired boilers brought about by their lying idle. Obviously, this condition results in a lower value for electrical energy than the previous condition considered.

Types of Electric Boilers

Electric-steam generators may be divided into two classes. The first, which will not be considered in this paper, includes the smaller capacity units and consists of immersion heating units enclosed in a pressure vessel. The other class, with which this paper is concerned, consists of a boiler shell in which electrodes are placed in such a manner that the current flows through the resistance of the water itself thereby generating steam.

Two general designs have been produced commercially. The recirculating type is shown in Fig. 1. Inside the boiler shell and surrounding the electrodes is suspended a metal basket pierced with small holes. A small centrifugal pump circulates the water from the bottom of the boiler shell to the basket from which that part of it which is not evaporated escapes through the holes back into the bottom of the boiler. By increasing the discharge of the pump the water can be caused to stand at higher levels in the basket thus resulting in increased electrode submergence and increased steam output.

* Abstract of paper presented at tenth annual general meeting of Engineering Section, Northwest Electric Light & Power Association, Portland, Ore., April 20-22, 1933.

Feedwater is introduced either into the basket or into the bottom of the boiler shell and water is blown off from a mud drum at the bottom.

Theoretically this type has several advantages. Load can be picked up and dropped off quite rapidly and it is readily adapted to automatic control. By means of the circulating pump the feedwater is constantly and thoroughly mixed with the boiler water and the concentration of the boiler water may be maintained at a uniform value at all points in the basket. However, in practice, as will be shown later, many difficulties are experienced unless the feedwater is unusually pure.

The other type of electric boiler, known as the Kaelin type after its inventor, is used in a great majority of installations. As shown in the sketch, Fig. 2, it is a very simple device consisting of a boiler shell and liner together with electrodes supported from bushings at the top of the boiler shell. The load is controlled by changing the water level or by changing the conductivity of the water in the boiler or by both of these methods. This type of boiler is quite free from any of the disadvantages inherent in the recirculating type and with proper design can be made to operate satisfactorily on either treated or untreated feedwater with a wide range of characteristics.

From available figures it appears that approximately 2,000,000 kw. of recirculating type electric boilers have been manufactured. Of the Kaelin type roughly, 1,250,000 kw. capacity have been installed, chiefly in paper mills in Canada. The range of voltages is from 550 volts up to 22,000 volts, with the majority of installations probably falling between the limits of 2300 to 6900 volts. The size of units runs from a few hundred kilowatts up to a maximum to date of 42,000 kw. Usually the larger units have a separate boiler shell for each phase. The maximum pressure to date is 250 lb. per sq. in.

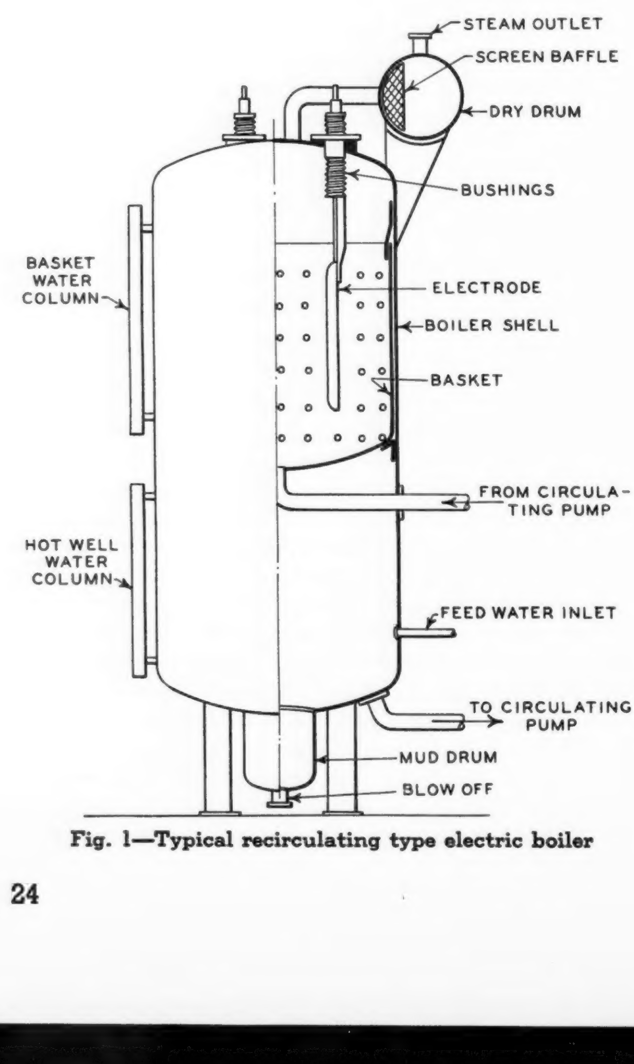


Fig. 1—Typical recirculating type electric boiler

Despite the apparent simplicity of the electric boiler, there are many factors which must be given consideration in its design and application. The comments which follow are drawn largely from experiments made on electric boilers dating back to 1924 when a 5000-kw., 2300-volt, 3-phase boiler of the recirculating type was installed. Except when limited by a shortage of electrical energy in low water years, this boiler has operated practically continuously at 4000 kw. and a pressure of 30 to 60 lb. per sq. in., the steam output going into the low-pressure heating mains. A great deal of difficulty was experienced with the recirculating feature due to the hardness of the feedwater which deposited scale and closed up the holes in the basket. This made it practically impossible to properly control the water level. The suction and discharge lines between boiler and pump and also the ports in the pump impeller became filled with scale, necessitating frequent cleaning. Therefore, several years ago the basket and circulating pump were removed and the boiler was rebuilt into the Kaelin type by installing a new liner and new electrodes. In 1932 an additional Kaelin type boiler rated at 5000 kw., 4000 volts, 3 phase, 175 lb. pressure was installed. This boiler operates in parallel with fuel-fired boilers at a pressure of 150 lb. supplying steam to the high-pressure heating mains and through reducing valves to the low-pressure mains.

Boiler Shell

Electric boilers are usually cylindrical with the axis vertical. The first boiler mentioned above had a removable gasketed head. Difficulty was experienced with leakage at the gaskets when the boiler was operated at high pressures and therefore its operating range has been limited to 60 lb. per sq. in. and less. A great deal of time is required to remove and replace the boiler head for cleaning and inspection. The piping and electrical connections are disturbed each time the head is removed with consequent possibility of damage to both thermal and electrical insulation. Therefore, in view of the difficulties experienced with the original boiler, the second boiler was designed of all welded construction with manholes for access to the inside for cleaning, inspection and changing electrodes.

To protect the boiler shell from any possible electrolysis it is protected by a boiler plate liner fastened by brackets to the inside of the boiler shell. This provides a path for the neutral currents without the possibility of weakening the boiler shell by corrosion. Proper shaping of the liner may also be used to secure more uniform current distribution at the electrodes.

Electrodes

A great variety of electrode shapes are used, a few typical examples being shown in Fig. 3. Very large boilers sometimes are built with a separate boiler shell and electrode for each phase, the separate units being connected by the steam header. Cast iron has been found the best material for electrodes due to its low cost, the ease with which it can be cast and its otherwise satisfactory properties.

Bushings

The design of the bushings for electric boilers present

problems entirely different from those encountered in any other type of electrical equipment. The weight of the electrodes may be from several hundred to a thousand pounds depending on the size of boiler and the type of electrode used. The generation of steam around the electrode and the rise of the steam bubbles through the water results in a certain amount of vibration, thus causing a bending moment at the bushing. The temperature of the bushing and bushing conductor ranges from room temperature when the boiler is shut down to the temperature of the steam inside the boiler when it is in operation. This range may be several hundred degrees and results in considerable expansion and contraction.

All the foregoing difficulties have been met by the use of a high strength porcelain bushing with the assembly held in compression by a strong spring. Well fitting gaskets must be provided to prevent leakage of steam into the space around the conductor where it could condense when the boiler is out of service and cause flashover when voltage was again applied. The portion of the bushing inside the boiler must be at a sufficient height above the water level to prevent splashing water from shorting it or depositing scale on the surface which would ultimately result in the destruction of the bushing by heating due to leakage current.

Feedwater

The element which determines to a great extent the characteristics of the electric boiler and the proportions of its component parts is the feedwater. The feedwater has a certain electrical conductivity depending on the chemical composition of its impurities. However, the conductivity of the water is not a stable quantity and is affected by several of the conditions which are present in the electric boiler during operation. Increase in temperature of the water tends to increase the conductivity. Likewise, except in a closed system where the condensate is returned to the boiler, evaporation of the boiler water and the constant addition of feedwater increases the concentration of dissolved solids in the boiler water and thereby increases the conductivity. Certain hard waters precipitate calcium salts as a sludge or hard scale. These salts which precipitate out when the water is heated do not appear to increase the electrical conductivity of the water to the same extent that salts which remain in solution do. These characteristics of feedwater are shown in Figs. 4 and 5.

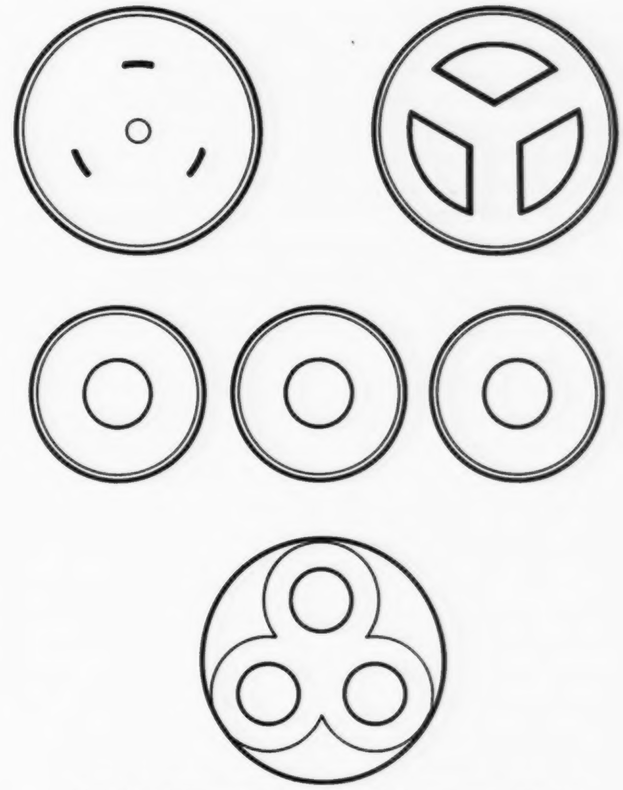


Fig. 3—Representative electrode arrangements

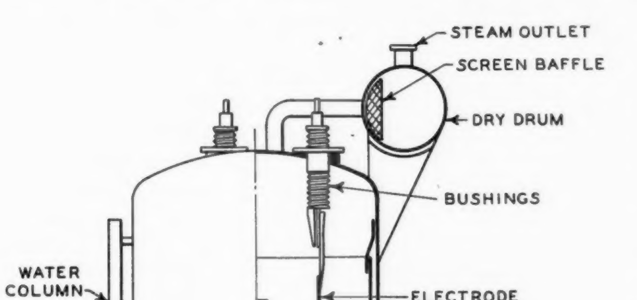


Fig. 2—Kaelin type electric boiler

From these curves it will be readily apparent that in order to determine the electrical characteristics of the boiler water during operation it is necessary to know the boiler water temperature (which is determined by the operating pressure) and the maximum probable concentration of solids in the boiler water, this factor being determined by the composition of the feedwater and the percentage of blowdown. Having determined these factors the unit conductivity of the boiler water can be found by proper tests. The phase-to-phase and phase-to-neutral conductivity of the water in the boiler are determined by the unit conductivity and the configuration of the boiler liner and electrodes. By the selection of the proper dimensions and proportions a design can be made which will operate at any desired kilowatt capacity and voltage rating within practical limits.

Operating Experience

The feedwater available for these electric boilers contains such large amounts of calcium salts that it is necessary to treat it in a zeolite water softener before it is fed to the fuel-fired boilers which are operated in parallel with the electric boilers. However, this treated

water was found unsuitable for use in the electric boilers because of its high conductivity, which factor would have made necessary either a very large boiler or a very low voltage. The size of boiler and voltage were determined by the space available and the voltage of the available transformers respectively. It was necessary, therefore, to use untreated city water in the electric boilers. This results in a large amount of precipitation, part of which is in the form of a sludge that is blown off from the mud drum and part in the form of a hard scale that deposits on the boiler liner and electrodes. When this deposit reaches a thickness of about one inch it scales off in large pieces and drops to the bottom of the boilers where a ton or more of it may collect over a period of several months before it is necessary to clean it out. Screens prevent the larger pieces of scale from stopping up the blowoff line from the mud drum. Because of this extreme hardness of the feedwater the Kaelin type boiler has been found to be the only satisfactory design for this installation.

Cold city water, after passing through the heat exchanger, is used for feedwater for both electric boilers. The water blown off from the high-pressure boiler is fed into the low-pressure boiler and all blowdown to waste through the heat exchanger is made from the low-pressure boiler. This operating plan enables one heat exchanger to be used for both boilers and also decreases the total heat transferred in the heat exchanger since a large part of the heat units in the high-pressure blowdown is released in the low-pressure boiler. Manual control of load is accomplished by controlling the water level and concentration of the boiler water by means of the feedwater and blowoff valves. Except when changing load a continuous flow of feedwater and blowoff is maintained and when the proper adjustment is once made the electric boilers operate with very little attention and at a very steady load.

As previously stated, the load is varied by changing the water level or by changing the concentration of the boiler water. Due to the relatively large size of the boilers these changes take considerable time and, therefore, the electric boiler is not well suited to rapidly changing loads. Full load can be picked up in about one hour from a cold start. Very light loads are not readily carried by the electric boilers. Operating in this manner requires either a very small submergence of electrodes or a low concentration of boiler water. The first condition results in rapid burning of the electrode tips and possibly in arcing and dissociation of the water. The latter condition requires excessive blowdown with the consequent losses.

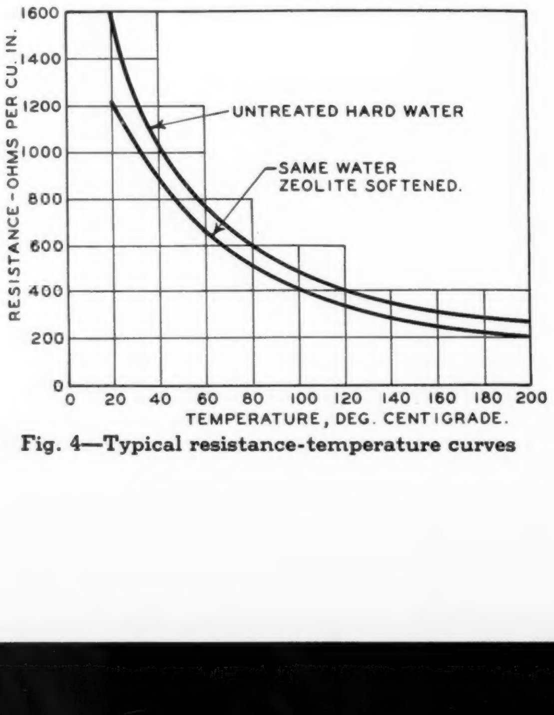


Fig. 4—Typical resistance-temperature curves

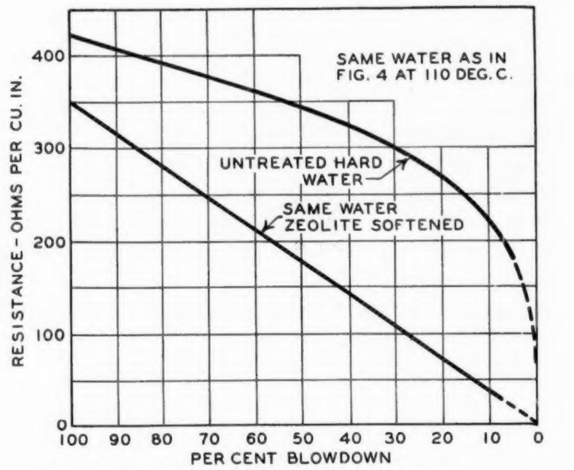


Fig. 5—Typical resistance-blowdown curves

The use of cold feedwater, which is heavy when compared with the boiler water at steaming temperature, has made it imperative to consider the circulation inside the boiler in arriving at the best point of introducing the feedwater and blowoff connections. The feedwater must be introduced into a turbulent zone preferably by a jet which will give it a high velocity. Otherwise it will not mix with the boiler water but will settle to the bottom and be blown down from the mud drum without having reduced the boiler water concentration. During the initial trial of these electric boilers, before the proper location of feedwater inlet had been determined, cold water was actually observed in the blowdown line with the boiler operating at full load. This was caused by the introduction of the feedwater at low velocity into a descending current of water which allowed it to settle in the non-turbulent area at the bottom of the boiler.

Experience has shown that the current density at the surface of the electrodes should not exceed 0.8 amp. per sq. in. for low-pressure boilers up to about 60 lb. per sq. in. At 150 lb. per sq. in. pressure, the smaller volume of steam per unit weight will permit satisfactory operation at a current density of up to 1 amp. per sq. in. If these limits are exceeded the steam forms so rapidly at and near the electrode surface that the water is momentarily forced out of contact with the electrodes and then flows back around them resulting in a very unsteady load.

An efficiency test of 120 hr. duration was made in December 1932, on the two electric boilers. On account of the interconnection of blowdown from one boiler into the other it was necessary to consider the two as a unit. When operated at full load, the over-all efficiency from switchboard to steam mains averaged 97.7 per cent over the five-day period. About 25 per cent of the losses could be accounted for in the electric cables and in the blowoff water wasted to the sewer from the heat exchanger. The remainder was radiation loss. One of the boilers was well insulated; the other, being of the older removable head type, had the insulation in only fair condition. The blowdown ranged from 8 to 10 per cent of the total feedwater but the greater part of the heat units in the blowdown water was recovered in the heat exchanger. An evaporation averaging 2.88 lb. of steam per kw-hr. was attained. Part of the steam

generated was at 150 lb. pressure; the remainder at 50 to 60 lb.

This efficiency is not out of line with that of other electric steam boiler installations. The operating efficiencies of eighteen electric boilers were reported at the 1931 convention of the Canadian Electric Association, and ranged from 90 to 98.5 per cent. Twelve of the 18 operated at 95 per cent efficiency or higher. Large size is not essential to high efficiency as is demonstrated by the fact that a 500-kw. installation reported an efficiency of 98 per cent.

The Superheater Company Takes Over Management and Sales of the Air Preheater Corporation

As of September 12, 1933, The Superheater Company, New York, acquired an interest in and assumed the management of The Air Preheater Corporation, Wellsville, N. Y., manufacturers of Ljungstrom air preheaters. The Air Preheater Corporation retains its corporate identity under new management, and will continue the manufacture of its products at its Wellsville plant. H. S. Colby will remain in the organization as vice-president. Its executive offices will be consolidated with those of The Superheater Company at 60 East 42nd Street, New York. Air Preheater sales activities will be coordinated with the Industrial Department of The Superheater Company, with headquarters at that address, and of which William T. Conlon has lately been made manager.

This arrangement broadens the activities of both The Superheater Company and The Air Preheater Corporation in the power equipment field. The Superheater Company, through its Industrial Department, handles the manufacture and sale of Elesco superheaters for all types and makes of boilers for public utility and industrial power plants. Also, economizers, desuperheaters, resuperheaters, furnace water walls and miscellaneous heat-exchange apparatus for power plants, oil industries and process industries.

The new officers of The Air Preheater Corporation are as follows: F. A. Schaff, president; H. S. Colby, vice-president; M. Schiller, vice-president and treasurer; T. F. Morris, secretary and assistant treasurer; H. S. Marshall, assistant secretary and assistant treasurer. The directors are George L. Bourne, chairman; W. L. Batt, H. S. Colby, R. M. Gates, F. A. Schaff and M. Schiller.

Determination of Carbonates, Phosphates and Hydroxides in Boiler Waters

Improved methods for the determination of carbonates, hydroxides and phosphates in boiler waters have been developed by a subcommittee of the Joint Research Committee on Boiler Feed Water Studies, which is sponsored by six of the leading engineering societies and associations in this country. These methods are described in three reports which have just been published by the A.S.M.E. They represent the results of a research program conducted over the past two years at the University of Michigan under Prof. A. H. White of that university and C. H. Fellows of the Detroit Edison Company, chairman of the subcommittee.

The purpose of publishing the methods at this time is to have them given practical trial and criticism by industry. From the results obtained Committee D-19 on Analysis of Industrial Waters of the American Society for Testing Materials will prepare standard methods of water analysis suitable for referee and control purposes.

The investigation on carbonate determination was financed by the Detroit Edison Company and the results made available to the subcommittee. The other two programs were financed by the Joint Research Committee from a grant made by the Engineering Foundation.

The Joint Research Committee on Boiler Feed Water Studies, S. T. Powell, Chairman, was organized in 1925 to study methods of analysis and treatment of boiler feedwater in stationary and railroad practice. The committee is sponsored by the American Boiler Manufacturers Association, The American Railway Engineering Association, The American Water Works Association, the Edison Electric Institute, the American Society for Testing Materials and the American Society of Mechanical Engineers. Besides the above mentioned program at the University of Michigan, the committee is also sponsoring an investigation of priming and foaming of boiler waters under Professor C. W. Foulk at Ohio State University and a study of alkalinity and sulphate relations in boiler salines at the Non-Metallic Minerals Experiment Station of the Bureau of Mines under Dr. E. P. Partridge.

The three reports have been reproduced in photo-offset form and bound together in one volume of approximately 100 pages. Copies may be obtained from the A.S.M.E. for $1.75 each. A further report of 100 pages has been prepared by the subcommittees and is entitled "The Determination of Sulphates in Boiler Waters." It contains a supplement indicating the possibility of using a direct titration method. Should sufficient requests be received for this report it will be made available in published form by the Society at not more than $2.00 a copy.

The Coppus Engineering Corporation, Worcester, Mass., has appointed Frederick D. Rogers, 80 Federal St., Boston, Mass., to handle sales in the states of Maine, New Hampshire, Vermont and the section of Massachusetts lying east of Worcester County. This territory was formerly covered from the home office. Mr. Rogers will handle the complete line of Coppus blowers, ventilating equipment, turbines and generators and the Annis Dry Type Air Filter for ventilating and industrial applications.

The Homestead Valve Manufacturing Co. has appointed D. W. Lawler, 1911 Rutherford Avenue, Louisville, Kentucky, as exclusive representative covering the Louisville District for the sale of the *Hypressure Jenny*, a vapor spray machine used for automotive, industrial, aeronautical and building cleaning.

Development of Formula to Determine CO_2 in Products of Combustion

By P. B. PLACE and J. CRUISE

Combustion Engineering Company, Inc.

The present article is complementary to a series by Mr. Place on "Derivation and Use of Common Formulas Used in Combustion Calculations" which dealt with the following phases of the subject. "Calculation of Weight of Dry Products of Combustion," July 1932; "Fuel Performance Calculations," October 1932; "Formulas for Calculation of the Amount of Air Required and Used for Combustion," and "Calculation of Heat Losses Due to Water Vapor in Products of Combustion," January 1933. This discussion is based on the mol system and is applicable to any fuel. A subsequent article by the same authors will deal with combustion characteristics of mixed fuels.

THE flexibility and advantages of the use of the "mol" system in dealing with combustion calculations is illustrated in the following development of a formula for the determination of the CO_2 content in the dry products of combustion of any fuel for any given amount of excess air. The development follows a logical sequence of steps that was explained in detail in a previous article.* Briefly the steps are:

1. Determine the oxygen required for complete combustion of the combustible elements present in the fuel.
2. Subtract whatever oxygen may already be in the fuel from the required oxygen to give the oxygen that must be supplied in the form of air.
3. Calculate the required air from the oxygen to be supplied, by dividing by 0.209 which represents the percentage by volume of oxygen in air.
4. Calculate the required air to total air by introducing an excess air factor.
5. Calculate the nitrogen in the total air by multiplying by 0.791 which represents the percentage by volume of nitrogen in air.
6. To the nitrogen from the total air, add any nitrogen that may already be in the fuel to give the total nitrogen appearing in the products of combustion.
7. Calculate the CO_2 and SO_2 formed from the total C and total S in the fuel.
8. Determine excess oxygen by multiplying the oxygen to be supplied by the per cent of excess air.
9. Total up the constituents of the dry products of combustion; that is, CO_2, SO_2, excess O_2 and total N_2.
10. The percentage of CO_2 by volume in the flue gases is then the ratio of the CO_2 formed over the total dry gases.
11. Similarly, the percentages of SO_2, O_2 or N_2 are the ratios of these constituents over the total dry gases.

* "Fuel Performance Calculations," COMBUSTION, Oct. 1932.

All of the above values are determined as mols on some chosen fuel basis. The basis recommended is 100 lb. of fuel as fired. A complete ultimate analysis of the fuel on an "as fired" basis is required.

It may appear illogical that percentage by volume of flue gas constituents can be directly determined from an analysis by weight of the fuel. The mol relationship is such that percentage by mol is the same numerically as percentage by volume and mol quantities are readily determined from weight values. If the number of mols of CO_2 per 100 lb. of fuel is divided by the number of mols of dry gases per 100 lb. of fuel, the result is a ratio of mols of CO_2 over mols of dry gases which is numerically the same as a ratio of volumes of CO_2 and dry gases.

In the table are given the various steps in the development of the final formula. The symbols C, O_2, S, N_2 and H_2 are percentages by weight of these constituents in the ultimate analysis of the fuel. The number of mols of each constituent in the fuel is the weight of that constituent divided by the proper molecular weight as shown in item B. On the basis of 100 lb. of fuel, there are C lb. of carbon in the fuel, H_2 lb. of hydrogen, etc. A mol is a molecular weight in pounds and therefore the number of mols of carbon in C lb. of carbon is C/12, where 12 is the molecular weight of carbon. Similarly, there are $\frac{H_2}{2}$ mols of hydrogen and $\frac{N_2}{28}$ mols of nitrogen, etc. Ash has no definite molecular weight and the number of mols of ash cannot therefore be determined. Since ash requires no oxygen for its combustion and does not appear in the products of combustion, it is not involved in the calculations.

The three combustible constituents of a fuel are the carbon, hydrogen and sulphur. The oxygen requirements for the complete combustion of these constituents are represented by the following chemical equations:

1. $C + O_2 = CO_2$
2. $H_2 + {}^1/_2O_2 = H_2O$
3. $S + O_2 = SO_2$

The symbols C, O_2, H_2, S, CO_2, SO_2 and H_2O represent molecules or mols and the equations state the mol relationships. Thus one mol of carbon requires one mol of oxygen to give one mol of carbon dioxide and one mol of hydrogen requires one-half a mol of oxygen to give one mol of water vapor, etc. The numerical subscripts in the above symbols may be confusing to one not familiar with chemistry but it is not essential that they be

understood. It should be noted that the C, O_2, H_2 and S in the above equations are not the same as the C, O_2, H_2 and S given in the fuel analysis. They both represent the same constituent but in one case they are percentages by weight and in the other case they are mols.

Since one mol of carbon requires one mol of oxygen for its combustion, $\frac{C}{12}$ mols of carbon will require $\frac{C}{12}$ mols of oxygen. Similarly $\frac{H_2}{2}$ mols of hydrogen will require one-half of $\frac{H_2}{2}$ mols of oxygen or $\frac{H_2}{4}$ mols. The total oxygen requirements of the fuel will therefore be the sum of the oxygen requirements of its combustible elements, carbon, hydrogen and sulphur or the required number of mols of oxygen will be $\frac{C}{12} + \frac{H_2}{4} + \frac{S}{32}$

Some oxygen may already be present in the fuel and therefore the mols of oxygen that will have to be supplied in the form of air are

$$\frac{C}{12} + \frac{H_2}{4} + \frac{S}{32} - \frac{O_2}{32}$$

Per cent by mol is the same numerically as per cent by volume and the above number of mols of oxygen to be supplied represent 20.9 per cent of the air that must be supplied, which is

$$\frac{C/12 + H_2/4 + S/32 - O_2/32}{0.209}$$

None of the other steps given in the table should require detailed explanation. The sequence of steps should be noted and followed carefully, differentiating particularly between required oxygen, oxygen to be supplied and required air. Note also the difference between nitrogen from total air and total nitrogen.

This sequence of steps will cover any type or composition of fuel. High sulphur and high nitrogen fuels cause no confusion. Gas, liquid or solid fuels are all handled in exactly the same manner when reduced first to an ultimate analysis by weight. Gas fuels containing carbon dioxide, methane and other compound constituents are reduced to an ultimate analysis of elementary constituents. Much simpler and shorter methods are available for handling some gas fuels but the object of this discussion is to demonstrate the development of a formula that is universally applicable to all fuels.

The final equation indicated in the table is, of course, cumbersome and impractical. It may be reduced to a more simple form as follows:

$$\text{Per cent } CO_2 = \frac{C \times 100}{(1.00 + 0.01E)\,(4.785C + 1.794S) + (1.00 + 0.0126E)\,(11.354H_2 - 1.419\,O_2) + 0.428N_2}$$

For low sulphur and low nitrogen fuels, an approximate formula may be used as follows: This simpler form is, of course, a special form.

$$\text{Per cent } CO_2 = \frac{C \times 100}{(1.00 + 0.1E)\,(4.8\,C) + (1.00 + 0.013E)\,(11.4\,H_2 - 1.4\,O_2)}$$

Another special form that is applicable to all fuels but gives the per cent CO_2 in the dry products of combustion for zero per cent excess air is

$$\frac{C \times 100}{4.776\,C + 11.352\,H_2 + 1.788\,S - 1.416\,O_2 + 0.432\,N_2}$$

which for low sulphur and low nitrogen fuels may be simplified further to

$$\frac{C \times 100}{4.78\,C + 11.35\,H_2 - 1.42\,O_2}$$

The latter formula, for example, gives, for a typical Pittsburgh coal, a value of 18.57 per cent theoretical CO_2 as compared with a correct value of 18.45 per cent obtained with the more complete formula.

DEVELOPMENT OF FORMULA FOR DETERMINATION OF CO_2 IN DRY FLUE GASES

A. Fuel analysis, per cent by weight
- Carbon = C per cent
- Hydrogen = H_2 per cent
- Sulphur = S per cent
- Oxygen = O_2 per cent
- Nitrogen = N_2 per cent
- Ash

B. Fuel (molecular analysis), mols per 100 lb. of fuel
- Carbon = C/12
- Hydrogen = $H_2/2$
- Sulphur = S/32
- Oxygen = $O_2/32$
- Nitrogen = $N_2/28$
- Ash

C.

1. Required oxygen, mols per 100 lb. of fuel
$$C/12 + H_2/4 + S/32$$
2. Oxygen to be supplied as air, mols per 100 lb. fuel
$$C/12 + H_2/4 + S/32 - O_2/32$$
3. Air to be supplied or required air, mols per 100 lb. fuel
$$\frac{C/12 + H_2/4 + S/32 - O_2/32}{0.209}$$
4. Total air supplied, mols per 100 lb. of fuel
$$\left(\frac{C/12 + H_2/4 + S/32 - O_2/32}{0.209}\right) \times (1.00 + 0.01\,E)$$
where E is the percentage of excess air.
5. Nitrogen from total air, mols per 100 lb. of fuel.
$$\left(\frac{C/12 + H_2/4 + S/32 - O_2/32}{0.209}\right) \times (1.00 + 0.01\,E) \times 0.791$$
6. Total nitrogen in flue gases, mols per 100 lb. of fuel
$$\left[\left(\frac{C/12 + H_2/4 + S/32 - O_2/32}{0.209}\right) \times (1.00 + 0.01\,E)\,(0.791)\right] + N_2/28$$
7. Carbon and sulphur dioxide formed, mols per 100 lb. of fuel
C/12 and S/32
8. Excess oxygen due to excess air, mols per 100 lb. of fuel
$$(C/12 + H_2/4 + S/32 - O_2/32) \times E/100$$
9. Total dry products of combustion, sum of items 6, 7 and 8, mols per 100 lb. of fuel.
10. Per cent by volume of CO_2 in dry products of combustion.
$$\frac{\text{item } 7}{(\text{items } 6 + 7 + 8)}$$

Electric Output Still Rising

Production of electricity by central stations continues to rise. For the week of September 30 the latest figures available through the Edison Electric Institute show a total of 1,652,811,000 kw-hr. which is an increase of more than 10 per cent over the corresponding week of last year. This is the twenty-second successive week that has shown an increase over last year, the turning point in utility output having been reached late in April. In the South, the central industrial states and the Rocky Mountain region the gain has been considerably greater than the average for the whole country, whereas in New England, the Middle Atlantic and Pacific Coast states it has been less. The affiliates of the Electric Bond & Share Company report increases, for the week ending September 23, of 23 per cent over the same period of 1932.

The Real Efficiency of a Power Plant

By N. T. PEF

The author discusses the real efficiency of a power plant as the ratio of the actual to the potential efficiency which, of course, is fixed largely by the design. To illustrate this he cites the experience of a station which, upon a change in personnel, set about systematically to approach the potential efficiency. Losses were sought and eliminated, operating procedure was altered and a fire-room bonus put into effect. The net result was an increase in overall plant efficiency to within 5 per cent of the potential with consequent savings of over $100 per day.

EFFICIENCY records are in vogue among power engineers and even in plants that are indifferently operated, records of performance are kept after a fashion. Boiler efficiencies of over 70 per cent are considered to be good operation although 90 per cent has been obtained. A few central stations have reached the 30 per cent mark in overall efficiency, and yet even 20 per cent is regarded as very good. With such wide limits, can any figure expressing efficiency mean very much? If records showed that a certain station generated electricity at 15,000 B.t.u. per kw-hr. should one conclude that it is efficiently operated? Quite the contrary might be the case. Or, of two boiler rooms, if one had an efficiency of 80 per cent and the other 75 per cent, does it necessarily follow that the latter is less efficiently operated than the former?

Of course, if a plant has economizers, employs the regenerative cycle and has other heat recovery equipment, a mental allowance is made for these, but efficiency depends on a great many other factors besides. Unless all are taken into consideration, the conclusions will be discordant.

Whether a power plant is efficiently operated cannot be judged from the conventional efficiency now in use. A plant with an overall efficiency of 27 per cent but whose possible efficiency is 30 per cent is not as economically managed as one with an efficiency of 19 per cent if its potential efficiency is 20 per cent. The second station approaches its ideal condition within 5 per cent while the first comes no closer than 10 per cent. That is, the true efficiency of a plant is the ratio of the actual to the potential efficiency, the potential being the highest that can be obtained under good operating conditions. The inherent losses subtracted from 100 give the potential efficiency or bogie, and the inherent losses are the minimum losses under good conditions.

In the table that follows are given the principal losses that are found in the typical boiler room, and to what extent they are inherent is indicated in the column at the right. These have been calculated for a plant of five boilers, 10,000 sq. ft. each, 400 lb. pressure, 600 fahr. steam temperature, 200 per cent rating, stoker-fired and having economizers.

		Per Cent
1.	Dry chimney gas	5.0
2.	Combustible in ash	2.0
3.	Moisture in the coal and air	1.0
4.	Loss due to hydrogen	5.0
5.	Radiation and minor losses	2.0
	Total inherent losses	15 0

The potential efficiency for the boiler room is (100–15) or 85 per cent.

The station whose boiler room has just been considered has an overall water rate under good conditions and during a normal day of 12.6 lb. per kw-hr., 1120 net B.t.u. per lb. of steam, or 14,100 B.t.u. per kw-hr. for the turbine room alone. The overall station efficiency then is (14,100–0.85 per cent) or 16,600 B.t.u. per kw-hr., which is equivalent to 21 per cent. This is the potential efficiency and not the actual. The actual efficiency of this station in reality was only 18 per cent and everybody was satisfied because it was believed that 18 per cent was good. In support of this argument other stations of about equal size were pointed out that had efficiencies below 18 per cent. But there was a change in personnel and when it was established that 21 per cent can be obtained with the installed equipment and under the given operating conditions, it took only one month to come within 5 per cent of this figure.

The first move by the new organization was to ascertain the maximum possible efficiency, and as a result of this study, the potential efficiency mentioned above was arrived at. The differential between these two efficiencies is 17 per cent and this necessarily is the composite of all the preventable losses and it was realized that the possible efficiency will be attained only when this margin is destroyed. The following procedure was adopted to bring about the increase in efficiency which was believed attainable.

1. All the losses that are possible in a central station were itemized and cataloged as shown in Table I.

2. The inherent portion of these losses was then determined and this was entered in the table opposite the loss as shown in the first column.

3. The preventable portion of the loss is the total minus the inherent and the third step was the measurement of the total of each individual loss. This was the most difficult part of the program and required a whole month for its consummation. The separate losses were attacked in rotation, starting from the top of the

list. If the total of any loss was the same as the inherent, this was prima facie evidence that this portion of the operation was 100 per cent. But if the total loss was greater than the inherent, all the energies were concentrated on the eradication of this margin before proceeding any further.

4. The coal used by this station had the following proximate analysis:

	Per Cent	
Moisture	11.0	
Volatile matter	35.0	(Round figures for yearly
Fixed carbon	43.0	average.)
Ash	11.0	
B.t.u. as received		11,000

Repeated tests of the flue gas showed that the boilers were being operated with CO_2 that varied from 9 to 15 per cent. The boilers were equipped with air meters but the firemen disregarded them, complaining that they were not accurate, and after careful inspection their claims were justified. The meters were tested and set and the men given detailed instruction as to the correct operation.

5. The temperature of the gas at the economizer exit was found to be slightly over 300 fahr. on some of the boilers and on others only 275. Since like causes produce like effects, the reason for 275 was sought and was found. The lower temperature was found with boilers that had been recently out for repairs and whose soot-blower elements were in good condition. It had been the practice to remove the slag from the front bank of tubes while a boiler was out, but aside from the routine soot blowing nothing else was done until the subsequent outage. Now the operators received orders to slag the boilers every night during bank and special tools were made for that purpose which consisted of long pipes with air hose attached. The soot-blowing elements were ineffectual against the slag which easily yielded to the hand manipulation. The flue gas temperature of all the boilers was lowered to 275 fahr.

TABLE I

Name of Loss	Inherent, Per Cent	Total, Per Cent	Preventable, Per Cent
Boiler Room			
1. Excess air	5.0	10.0	5.0
2. Flue gas temperature (higher temperature than what is possible under the conditions)	0.0	1.0	1.0
3. Combustible in the ash	2.0	2.0	0
4. Radiation, moisture in coal and air	2.0	2.0	0
5. Hydrogen	5.0	5.0	0
6. Banked boilers	1.0	2.0	1.0
7. Faulty operation (as high or low rating)	.0	1.0	1.0
8. Incomplete combustion	0	0	0
9. Leaks	0	1.0	1.0
Turbine Room			
10. Utilization of exhaust steam	0	1.0	1.0
11. Co-ordinated use of the auxiliaries	0	.5	.5
12. Fluctuating steam pressure and temperature	0	1.0	1.0
13. Condenser vacuum	0	.5	.5

6. (Loss No. 7.) It was found that these boilers had their most economical point at 180 per cent rating. Since this information was not known previously, operation as to rating was at random. Armed with this knowledge, a determined attempt was made to operate the boilers at this rating as closely as possible. Each day at 5 p.m. the boiler-room foreman was handed a schedule which outlined the method of boiler operation as to number, etc. Unwarranted banking losses due to leaks were also eliminated.

7. The efficiency of the boiler room was boosted by these means from 78 to 85 per cent or an increase of 7 per cent. In order to retain this gain with the least effort it was decided to enlist the cooperation of boiler-room operators by means of an incentive which consisted of a quarterly prize of $25 to be divided among the three firemen and their three helpers. The division of the prize was as follows:

First prize,	fireman $10;	helper $5
Second prize,	fireman 4;	helper 2
Third prize,	fireman 2;	helper 2

Firemen changed shifts in rotation and in three months conditions as to night shift (which is less efficient) and day shift were equalized, so that the three-month cycle of performance was a good indication of the effort and diligence exercised. Every three months the efficiency of each pair was computed and prizes paid accordingly.

8. (Loss No. 10.) Heating of the condensate was by means of exhaust steam in the open heater but the exhaust steam available and the heat required by the feedwater were not balanced. During light loads considerable exhaust steam was lost. This was taken care of in the following manner. The house unit was fitted so as to be regulated as to load from the main switchboard but as no advantage had been taken of this provision, the remote control was not functioning. This was put in order and also a $^1/_4$-in. pipe line was run from the heater to the switchboard where the pipe terminal was fitted to a mercury-filled U-tube. The switchboard operator was instructed to maintain a 1-in. pressure in the heater at all times by varying the load of the house unit. This ended the loss due to escaping steam.

9. (Loss No. 12.) The units were designed for operation at 400 lb. pressure and 600 fahr. temperature but in actual practice the pressure and temperature were allowed to fall about 10 points or more below the specification. A large master gage was installed in the firing aisle whose enlarged graduation made the execution of the injunction to maintain constant pressure easier. The temperature was also brought up to standard by augmenting the regular soot blowing of the superheater with hand air lancing.

10. (Loss No. 13.) There were two circulating pumps to each condenser and by actual test it was found that during heavier loads an increase in vacuum could be obtained with the two pumps in operation that would offset the extra expense of running the second pump. Accordingly, arrangements were made to run the second pump when conditions warranted.

The total increase in efficiency crystallized through this program was 12 per cent and the margin of preventable losses was cut to a point where the actual efficiency of the station was within 5 per cent of the potential efficiency. Since this station had a fuel bill of about $1000 per day, the daily savings exceeded $100.

The Smoot Engineering Corporation, manufacturers of Smoot Control, have moved their general offices and factory to Summit, New Jersey, where they have set up complete engineering and manufacturing facilities for their apparatus. Their former address at 136 Liberty Street, New York City, is still maintained as a sales office, with H. R. Kessler in charge.

Papers at A.S.M.E. Annual Meeting

The A.S.M.E. Annual Meeting will open on December 5 with a three-session Symposium on Heat Transfer, which promises to be of unusual interest and value. In the symposium are papers contributed by the A.S.M.E. Divisions on Petroleum, Power, Iron and Steel, while the following societies are also contributing papers: American Society of Heating and Ventilating Engineers, American Society of Refrigerating Engineers and the American Society of Steel Treating.

Tuesday, 9:30 a.m., Dec. 5—Heat Transfer

Heat Transfer Rates on Condensing, Reboiling and Miscellaneous Heat Exchange Services, Max Higgin, Texas Company, New York

Application of Fouling Factors in the Design of Heat Exchangers, E. N. Seider, Foster Wheeler Corporation, New York

Rates of Heat Transfer to the Radiant Heat Absorbing Section of Pipe Stills, Charles E. McCullough, Foster Wheeler Corp.

Cleanliness Factor—Its Accuracy and Influence on the Other Commercial Factors for Surface Condensers, P. H. Hardie and W. S. Cooper, Brooklyn Edison Company

Tuesday, 2:00 p.m., Dec. 5—Heat Transfer

The Effect of Angle of Emission on the Radiating Power of Various Oxidized Metal Surfaces (Report of Sub-Committee D, Heat Transmission National Research Council, R. E. Binkley, Lehigh University)

Fuel Fired Heat-Treating Furnace Transfer Rates, M. Mawhinney, Electric Furnace Company (A.S.S.T. paper)

Transfer of Heat in Electric Furnaces—General Electric Company (A.S.S.T. paper)

Discussion on Operating Data on Heat Transfer in Iron and Steel Plants by a group of discussors (A.S.M.E. Iron & Steel Division)

Wednesday, 2:00 p.m., Dec. 6—Heat Transfer

Heat Transfer Rates in Refrigerating and Air Cooling Apparatus, W. J. King, General Electric Company

Heat Transfer in Mercury Systems, W. T. Moore, Babcock & Wilcox Company

The Fuels Division is holding a session on Tuesday morning and presenting the following papers:

Report of Sub-Committee on Removal of Ash as Molten Slag from Powdered Coal, Percy Nicholls, Bureau of Mines

Burning Characteristics of Pulverized Fuels and Radiation from Their Flames, R. A. Sherman, Battelle Memorial Institute

On Wednesday morning the Industrial Power session will be held with the following papers:

Cooperation between Industrial and Public Utility Companies in the Generation of Steam and Electric Energy, H. D. Harkins, E. I. duPont de Nemours & Company

Some Broader Aspects of Planning for Industrial Steam and Supply Projects, Vern E. Alden, Stone & Webster Engineering Corp.

The Central Station sessions will be Thursday morning and afternoon, Dec. 8, and will include the following papers:

The Thermal Performance of the Detroit Turbine Using Steam at 1000 fahr., Prof. F. O. Ellenwood, Cornell University and W. A. Carter, Detroit Edison Company

High-Temperature Steam Experience at Detroit, P. W. Thompson, Detroit Edison Company

Supersaturated Steam, John I. Yellott, University of Rochester

Leaving Velocity and Exhaust Loss in Steam Turbines, E. L. Robinson, General Electric Company

Among the other sessions of interest to the power field will be an Oil and Gas Power session on Wednesday morning, a Steam Tables Research session on Wednesday afternoon, a Boiler Feed Water session on Thursday afternoon, an Air Conditioning session on Thursday afternoon held jointly with the American Society of Refrigerating Engineers. Design sessions that are also of interest are, two sessions on Tuesday of the Hydraulic Division on Water Measurement, one session on Fluid Meters and a session on Plasticity which includes a report by the Research Committee on Effect of High Temperature on Properties of Metals.

The National Board of Boiler and Pressure Vessel Inspectors will hold their Ninth Annual Convention at the Hotel McAlpin, New York City, on October 17, 18 and 19. An extensive program on subjects of particular interest to the members has been prepared. Among the speakers will be Dr. D. S. Jacobus, Chairman of the A.S.M.E. Boiler Code Committee; Charles E. Tudor, President of the American Boiler Manufacturers Association; and James A. Beha, General Manager and Counsel of the National Bureau of Casualty and Surety Underwriters. Two sessions will be held daily, a luncheon each day at the hotel and a dinner on Tuesday evening at which L. C. Peal will be toastmaster. Election of officers will take place on Thursday afternoon.

D. E. Karn, formerly assistant general manager of the Consumers Power Company, Jackson, Mich., has been appointed vice-president and general manager of that company to succeed Charles W. Tippy.

The Allen-Sherman-Hoff Company announces that it is now being represented in the Chicago territory by the Diamond Power Specialty Corporation, 20 N. Wacker Drive, Chicago.

At a recent meeting of the board of directors of the Buffalo, Niagara & Eastern Power Corporation, Col. William Kelly, vice-president and general manager, was elected president to succeed Alfred H. Schoelkopf, who will move his business headquarters from Buffalo to the New York office of the Niagara Hudson Power Corporation, of which he is executive vice-president. Alex D. Robb was elected as Col. Kelly's successor to the office of vice-president and general manager.

The Tennessee Electric Power Company, at a recent meeting of its board of directors, elected J. C. Guild, Jr., president and general manager, succeeding B. C. Cobb, resigned. W. L. Wilkie, president of the Commonwealth and Southern Corporation, was elected a director at the same meeting.

Prime Movers Report on Stoker Equipment and Furnaces

THE Edison Electric Institute has just issued the 1933 report on "Stoker Equipment and Furnaces," compiled by the Prime Movers Committee of the former N.E.L.A. This report, of which the following is a review, represents practice and operating experience of the member companies with stokers, furnaces, fans, air preheaters, cinder catchers and combustion control. Statements by equipment manufacturers as to developments, modifications in existing designs and recent installations are included in the report.

Stokers

There has been little change in stoker practice since the preceding report was issued and no noteworthy large stoker installations have been made in the interim. However, a table is included giving data on recent installations in the utility, municipal and industrial fields.

Several companies report changing from stoker firing to gas or oil where local conditions favored such a change. In one plant the grates were covered with cinders, then a layer of concrete, and a layer of firebrick on the furnace side. In another the tuyères, feed wedges, rams and air distributing boxes were removed, as well as the hopper and driving mechanism, and the supporting framework covered with $^1/_2$-in. plate over which was placed two layers of brick on edge and a light covering of cinders. In still another, the oil burners were located in the space provided by removing the rear section of the stoker and the front section and ashpit floored over. The burners were arranged to fire vertically upward. Other changes in these plants included altering baffles to maintain the desired superheat, covering the base water-wall tubes to maintain final steam temperatures with natural gas and the abandonment of automatic combustion control in favor of manual control in some instances where this fuel was burned.

The Detroit Edison Company reports having discontinued the practice of reclaiming and burning fines from economizers and air preheaters discharged into the ashpit, because of unfavorable ashpit conditions and the formation of large clinkers. Also, maintenance costs were high due to high temperature and reverse flow of gases when the discharge pipes were empty. On the other hand, at the plants of the Edison Electric Illuminating Company of Boston all material collected in the cinder catchers is burned satisfactorily by blowing it into the furnace with an air jet, and the Potomac Electric Power Company has had satisfactory results by returning these unconsumed fines through the rear wall of the furnace by means of an ejector.

Some companies report difficulty in maintaining satisfactory fuel bed conditions and air supply over wide ranges of output. The installation of baffles under the grates is offered as one solution. One company reports that the boiler can be brought up from bank to 335 per cent rating in 25 minutes. While one company states that the use of preheated air above 400 fahr. would result in increased stoker maintenance, another is employing 490 fahr. satisfactorily. At the James H. Reed Station in Pittsburgh, with the maximum rated capacity of 350,000 lb. of steam per hr. coal is burned on the stokers at the rate of 62 lb. per sq. ft. of grate area per hr. Best performance under present conditions is obtained with a thin, uniform and rapidly moving fuel bed.

Furnaces

Covering portions of initially bare water walls with refractory is reported as an aid in obtaining higher steam temperatures. This does not reduce the maintenance cost, and it is reported that plastic insulation so used is not permanent.

Erosion from slag and ash, insufficient circulation and overheating, cracks from fin tubes and mud in headers are mentioned as common water-wall troubles. Circulating tubes do not appear to safeguard against rupture. The installation of slag ledges at the furnace walls to prevent slag from dropping onto the end retorts and side tuyères has been found helpful in two cases reported.

Fans

All companies reporting state that no fuel bed disturbances or smoke are chargeable to fan speed changes. Vibration, caused by misalignments, changes in foundation, uneven erosion of blades and deposits of fly ash and cinders on the blades (where wet-type cinder catchers are employed) is reported in a number of cases, as is also erosion of blades and wearing plates.

Air Preheaters

Considerable difficulty is reported through fouling and corrosion in air preheaters. This was more pronounced with stoker firing and with preheaters of the bent-tube construction. On the other hand, some companies have experienced little trouble. The Philadelphia Electric Company reports in detail on air preheaters at the Chester Station. In one unit of the tubular type 341 out of 1350 tubes were replaced after eight years of service and it is estimated that the full cycle of preheater maintenance will have been completed in eleven years. On another unit of the rotating type at this station the maintenance cost has been 2.2 cents per sq. ft. per year.

Combustion Control

All the companies reporting agree that automatic control is more accurate and gives better regulation than hand control and one company is of the opinion that the cost is justified by possible reduction in operating personnel. It appears to be of prime importance in anticipating and functioning on load swings. On the other hand, one company has found it more desirable to control the coal feed manually. With the exception of stoker speeds, experience of the various companies indicates that control is automatic from 90 to 100 per cent of the time. Many are of the opinion that automatic regulation of stoker speed is so affected by variables that its use here is questionable.

NEW EQUIPMENT

of interest to steam plant engineers

Contact Gages

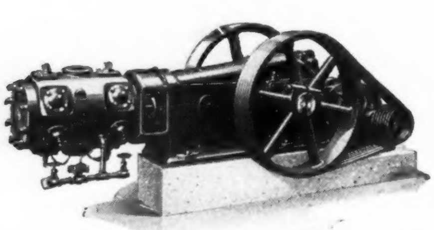
A line of compact, electric contact gages for draft, pressure and differential draft or pressure in ranges between one-tenth in. water and 100 in. water is announced by The Hays Corporation, Michigan City, Indiana. These gages are offered for either high or low contact service or for both, equipped with closed mercury switches or open contacts, depending on service conditions. The small cast aluminum case can accommodate either one or two single or double contact units or a single or double contact unit and a

second unit which indicates on a 3-in. scale the pressure or draft being measured. For differential draft or pressure the case is made air tight. Sensitive adjustments across the range selected are provided.

These contact gages are intended for applications where it is desired to sound an alarm or light a bullseye when certain pressures reach a predetermined high or low point, or where used in conjunction with intermediate devices are employed to open and close dampers, start and stop fan or vibrator motors and in similar application within their pressure range.

Compressor Equipment

A new single-stage, belt-driven compressor designed for heavy-duty service is announced by Ingersoll-Rand Company, 11 Broadway, New York. It is designated the Class ES. It has one horizontal, double-acting cylinder and operates at moderate speeds. It is available in sizes from 10 to 125 hp., and for discharge pressures from 5 to 150 pounds.

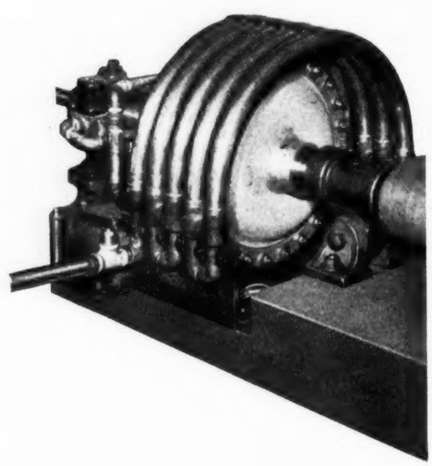


The machine is suitable wherever full-load, continuous service is required and wherever power cost is an important consideration. It will give economical stand-by service for large compressors whose full capacity is not always needed. It is well adapted for use in isolated plants where there is little supervision, for all applications where oil in the discharge line is objectionable, or for installations where a future change in pressure conditions may call for a change in cylinder size.

Low air speeds and small pressure losses obtained by liberal design of air passages and valves insure maximum economy. These features and effective water jacketing also insure low air temperatures, which simplifies lubrication problems and lengthens the service life of valves, cylinders and piston rings. A double row of Timken tapered-roller bearings on each end of the crankshaft reduce friction, make bearing adjustments unnecessary for a long time, and provide rigidity against all strains.

Hydraulic Coupling

The American Blower Corporation, Detroit, Michigan, announces a newly developed hydraulic coupling which makes possible variable speed control with a constant speed driver. It is designed especially for controlling and varying the speed of centrifugal pumps. This coupling, which will deliver 130 hp. at 3600 r.p.m., is applicable for use with a simple induction motor to replace the slip ring



motor in pump operation. It is claimed that it will eliminate the loss of power incurred where throttle valves are used, and that the exact speed for any desired load may be readily obtained without sacrifice of power.

New Lubricant

A new lubricant has been developed in which metallic lead is the protective element. The lead has been broken down into such finely divided parts as to be virtually a soluble or liquid lead within a lubricant vehicle.

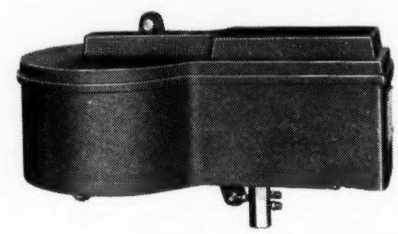
The new product, known as Bestolife, forms a thin protective film of lead on all contacting surfaces which changes such surfaces to a continuous unbroken, anti-frictional area, according to the manufacturers, Armite Laboratories of Los Angeles.

The minimum constituency of lead in Bestolife is 10 per cent, ranging up to 65 per cent and is claimed to withstand temperatures up to 430 fahr. and will not entirely lose its lubricating stability until the melting point of lead is reached, which is 590 fahr. The principal application of the product in the power industry is as a pump and valve stem packing lubricant, also for plug cocks, bearings, gears, wire line and belt dressing.

Furnace Draft Regulator

A compact draft regulator for use with boilers up to 200 hp. has recently been added to the Carrick Engineering Company's (Michigan City, Indiana) line of combustion control equipment.

The design is based on the principle of the beam scale. The draft is automatically "weighed" until the amount of draft for which it has been set is secured, after



which this draft is automatically maintained in balance by the regulator. A bell, suspended from a beam, immersed in an oil seal, is the means used to measure the draft. No diaphragm is employed and the draft is applied to the under side of the bell, above the oil line.

Smoke Density Indicator and Recorder

Photoelectric equipment for indicating and recording the degree of density of smoke passing through the stacks or breechings of power and heating plants, has been announced by the General Electric Company. Changes in smoke density are indicated on a meter. A running record of the amount of smoke passed up the stack may be obtained by the addition of a recording instrument.

The essential elements of the apparatus are a light source and a photoelectric relay unit. The recording instrument is optional. The photoelectric unit and the light source are designed for mounting on opposite sides of the stack so that the light beam from the light source passes through the stack and falls on the phototube. When there is no smoke in the stack the full intensity of the light is directed on the phototube and the indicating or recording instrument will register zero smoke density. As the smoke density increases, the phototube receives less light from the source and the instrument indicates or records the increase of smoke.

Lenses are provided in front of the phototube and light source. Clean air is drawn by the induced draft of the stack across the lenses, which assists in keeping them clean. The lenses will require some cleaning, however, and therefore the apparatus has been designed so that the lenses are easily accessible.

NEW CATALOGS AND BULLETINS

Any of the following publications will be sent to you upon request. Address your request direct to the manufacturer and mention COMBUSTION Magazine

Combustible Gas Analyzer

Bulletin 255 entitled Bacharach Combustible Gas Analyzer, Model RZA, sets forth the principle of operation and the essential features of construction and design of this analyzer. This bulletin includes diagrams and photographic reproductions. 6 pages, $8^1/_2 \times 11$—Bacharach Industrial Instrument Company, 7000 Bennett Street, Pittsburgh, Pa.

Compressor Equipment

A very comprehensive catalog has been recently issued describing the Ingersoll-Rand Heavy Duty Compressor. This compressor is suited for air or gas and is of the single-stage, double acting, horizontal, crosshead type, designed to run at moderate speeds and built for heavy continuous service. It is built in sizes ranging from 10 to 125 hp. and for pressures from 5 to 15 lb. Charts, tables, photographic reproductions, etc. 20 pages and cover, $8^1/_2 \times 11$—Ingersoll-Rand Company, 11 Broadway, New York.

Feed Water Regulators

Booklet No. 133 recently issued is entitled, "The Copes Double Control Regulator." It describes and illustrates this new regulator which feeds water to the boiler according to the rate of steam flow with correction for water level changes. It includes diagrams, performance reports and curves, and complete specification data. $8^1/_2 \times 11$, 8 pages—Northern Equipment Company, Erie, Pennsylvania.

Flue Gas Analyzers

Catalog TSE33 entitled Hays Flue Gas Analyzers and Portable Combustion Test Sets, describes and illustrates the principles of operation and the construction of various types of Hays Gas Analyzers and also portable test sets. The catalog is comprehensive and includes many diagrams and charts. $8^1/_2 \times 11$, 24 pages—The Hays Corporation, Michigan City, Indiana.

Gas Burners

A catalog entitled the Mettler Entrained Combustion Gas Burners sets forth much information relative to the above burners. Construction and capacity details, useful combustion engineering data and line drawings showing Mettler burner installations in boiler and industrial furnaces, are included. Tables, charts and an index. 48 pages and cover, $8^1/_2 \times 11$—Lee B. Mettler Company, 406 S. Main Street, Los Angeles, California.

Handling the Orsat

Bulletin No. 2006 is a reprint of an article by F. P. Elliott reprinted from *Oil Heat*. This article is written in conversational style and was planned to make the handling of an Orsat or gas analyzer as simple as the A B C's. The subject is gone into at some detail and is very easy to follow. Many illustrations are included graphically supplementing the descriptions and discussions. Various Hays analyzers are described at the back of the reprint. 16 pages, $8^1/_2 \times 11$—The Hays Corporation, Michigan City, Ind.

Recording Flow Meter

A pamphlet has recently been published describing the Foto-Flo Meter. This recording and indicating flow meter has no moving parts. The principle of operation, its construction and application are discussed at length. Diagrams and other installations are included. 4 pages, $8^1/_2 \times 11$—The Trimount Instrument Company, 332 So. La Salle Street, Chicago, Illinois.

Refractories

Carbex Water Gas Generator Linings is the title of a pamphlet recently issued. This pamphlet sets forth how to line water-gas generator furnaces to reduce the cost of de-clinkering, cleaning and maintenance. It contains tables and data of value to those in charge of gas production. 4 pages, $8^1/_2 \times 11$—McLeod & Henry Company, Troy, New York.

Refractory Products

A pamphlet has recently been issued describing the Zero refractory products. This name was heretofore applied only to high temperature cements, dry and plastics of the Standard Fuel Engineering Company, 667 Post Avenue, S., Detroit, Michigan, but it is now used to designate all the refractory products of that company. General information of a technical nature is included, with reference to the applicability of the Zero products in the field of high temperatures. 6 pages, $8^1/_2 \times 11$.

Screw Conveyors Data Book

A data book containing engineering data and list prices on Caldwell Helicoid and Sectional-Flight Screw Conveyors has been compiled and has just been printed. The book is profusely illustrated. 128 pages and cover—Link-Belt Company, 2410 W. 18th Street, Chicago, Illinois.

Steel-Cased Settings

A new booklet has been issued describing the design, construction and advantages of the Plibrico Steel-Cased Setting. This setting eliminates air infiltration and is adequately insulated. It is adaptable to both h.r.t. and water-tube boilers. It can be air cooled at practically no additional expense, furnishing pre-heated air where desired. 8 pages and cover, $8^1/_2 \times 11$—Plibrico Jointless Firebrick Company, 1800 Kingsbury Street, Chicago, Illinois.

Thermometers

A pamphlet has just been released describing and illustrating the construction, design and advantages of the Foxboro Dial-Type Thermometer. 4 pages, $8^1/_2 \times 11$—The Foxboro Company, Foxboro, Massachusetts.

Underfeed Stoker

The New Improved Jones Side Dump Stoker is the title of a recently issued catalog. A very comprehensive description of the stoker is set forth with many illustrations showing the construction details. A large number of line cuts shows the various types of boiler units to which this type of stoker is applicable. In addition many statements from customers are used to show their endorsement of the Jones Side Dump Stoker and bring out the performance and investment advantages as experienced by customers. 24 pages and cover, $8^1/_2 \times 11$—Riley Stoker Corporation, Worcester, Massachusetts.

Valve Data Book

A new source of information on valves and valve layout is the new catalog No. 23 just published by Jenkins Bros., 80 White Street, New York. This book described 400 Jenkins Valves, in a wide range of types and patterns, and gives complete details. All features of design and construction are clearly and fully described. Full information is given about the metals used in making the valves. Services, pressures, temperatures and fluids for which the valves are recommended are stated. The latter section of the book contains many pages of engineering data that are constantly needed where valves are used. 264 pages and cover.

Valve Trim

A booklet entitled "The One Best Valve Trim" describes the valve trim material developed by The Edward Valve & Manufacturing Company. This interesting booklet goes into the technical features of the material, its chemical analysis and physical characteristics and its performance under various conditions. Photo-micrographs of various metals are shown, together with product and laboratory illustrations. 12 pages, $4^1/_2 \times 6^3/_4$—The Edward Valve & Manufacturing Company, East Chicago, Indiana.

NOTICE

Manufacturers are requested to send copies of their new catalogs and bulletins for review on this page. Address copies of your new literature to

COMBUSTION
200 Madison Ave., New York

ENGINEERING BOOKS

1—Handbook of Oil Burning

By Harry F. Tapp

629 Pages Price $3.00

Contains information of practical value to the engineer or contractor whose work requires a knowledge of oil burning, heating or power equipment. Covers comprehensively the industrial application of oil as fuel, with drawings, illustrations and tables of this style of installation. Also discusses the various types of oil burner and principles of construction, oil burner controls and motors and fuel tanks and storage. Contains also a wealth of general information such as the chemistry of combustion and flame, fundamentals of heat and heat transfer, the determination of heating capacity requirements and comparative fuel costs.

2—Nature of a Gas

By Leonard B. Loeb

153 Pages 6 × 9 $2.50

This book presents in an exceptionally clear manner the essential facts covering atomic and gaseous structure. It will serve as an excellent introduction to engineers and industrial technicians on the electrical properties of a gas as a preparation for more advanced and technical monographs on the subject. The volume is brief, concise, but gives all necessary data on the breakdown of solid and liquid dielectrics.

The book is developed in an interesting and logical manner, and is the only compilation of reliable data on electrical properties of gases. It will appeal to physicists, chemists, electrical engineers and all those who work on electrical problems in which a gas is used as an insulator or conductor, or where its presence modifies the main phenomenon.

3—Mechanical Engineers' Handbook

By R. T. Kent

2247 Pages 10th Ed. Price $6.00

Designer, power-plant engineer, shop-superintendent, heating and ventilating engineer, hydraulic engineer, building constructor, foundryman, automotive engineer, will find this handbook to be a complete reference book covering their field and many others. "Kent" is more than a book, it is a complete library of engineering practice.

4—American Society of Heating and Ventilating Engineers Guide, 1933 (11th Edition)

592 Pages 6 × 9 Price $5.00

The 11th annual edition of this standard reference volume on heating, ventilating and air conditioning has been extensively enlarged and revised to include the latest results of research and modern engineering practice. The Guide 1933 embodies in its 45 chapters not only data developed at the A.S.H.V.E. Research Laboratory and cooperating institutions, but also the most practical and useful ideas of outstanding engineers in the profession.

The 592 pages of text matter in The Guide are supplemented by the valuable Catalog Data Section of Modern Equipment, in which detailed descriptions, sizes, capacities and dimensions of manufacturers' products are given.

5—Water Analysis

By Herbert B. Stocks

135 Pages $3.50

Public health officers, city chemists and those engaged in the study of this branch of analytical work will be interested in this new edition of a book which has long been a standard in this country and England on the subject of the methods adopted for the analysis of water for sanitary and technical purposes. It has been completely revised, rearranged and added to by W. Gordon Carey.

Modern developments have necessitated new sections dealing with hydrogen ion concentration, the determination of free chlorine in chlorinated water, and the determination of iodides. A section on simple bacteriological methods is included in this edition, and should prove of service to those who use this book.

6—The Engineers' Manual of English

By W. O. Sypherd and Sharon Brown

526 Pages Price $2.00

The Engineer's Manual of English is a practical guide for all technical writing which the engineering student may need to do while in college and later on in connection with his professional duties.

The book is divided into two parts: "Engineering Writing" and "Specimens of Engineering Writing." The first part deals with the application of the principles of formal rhetoric to the actual problems of the engineer-writer. The second part comprises a complete collection of specimens of engineering writing.

7—Economics for Engineers

By E. L. Bowers and R. H. Rowntree

490 Pages 6 × 9 Price $4.00

A practical presentation of economic principles and problems for engineers and engineering students. The treatment is as concise as possible and emphasizes the engineering aspects of economic theory and business activity. The discussion of costs and pricing is especially thorough. Some aspects of business activity, such as marketing, investments and insurance, not ordinarily included in texts on economics, are treated here for the convenience of the engineering audience to whom the book is addressed.

8—Industrial Gas Series—Combustion (Third Edition)

207 Pages Price $2.00

Although a third edition, this book, prepared under the supervision of the Committee on "Combustion" of the Industrial Gas Section of the American Gas Association, has been so completely revised both with respect to content and treatment that it is in reality a new book.

The following chapter headings give a good idea of the scope covered by this book: Heat and Its Measurement; Gas Volume and Pressure; Chemistry of Combustion; Thermal Capacity; Heat Transfer; Combustion Data of Commercial Gases; Atmospheric Burners; Industrial Combustion Equipment; Temperature Control; Heat Salvage Methods; Gas Analysis; Fuel Comparisons.

9—Bailey's Handbook of Universal Questions and Answers (Sixth Edition)

264 Pages $4^3/_4 \times 6^1/_2$ Price $2.00

The questions and answers contained in this Handbook are those that have been universally asked by examining boards and were compiled from over four hundred examination papers, including tests for firemen, engineers and boiler inspectors. It gives information on the subject of boilers, pumps, fuel consumption, valves, heating systems, engines, etc., and will be of assistance not only to those studying for any grade of license in this country or in Canada but also to the practical engineer and fireman.

The author, A. R. Bailey, is intimately acquainted with the needs of practical engineers and firemen and of candidates for licenses, having served as engineer and boiler inspector in the states of Massachusetts, Ohio, Pennsylvania and Michigan, and as safety engineer for the Lincoln Motor Company, Detroit. The sixth edition of this book, recently published, has been brought thoroughly up to date.

Postage prepaid in the United States on all orders accompanied by remittance or amounting to five dollars or over.

COMBUSTION, PUBLISHING COMPANY, INC.
200 Madison Avenue, New York.

Enclosed find check for $.........for which please send me the books listed by number

NAME ....

ADDRESS ....

Book Nos. ....

REVIEW OF NEW TECHNICAL BOOKS

Any of the books reviewed on this page may be secured from In-Ce-Co Publishing Corporation, 200 Madison Avenue, New York

Industrial Piping

—A Case Book of Proven Practices and Methods

THE practical considerations required in planning a new or remodeled piping system call for wide experience and seasoned judgment as well as engineering skill. On every job it is necessary to compromise between precise calculations and "rule-of-thumb" methods. How can the original plan be changed to fit the available appropriation? How shall the specifications be altered so materials may be ordered in commercially available sizes? Again, serious consideration must be given to first cost versus final cost. At every fitting, joint and bend there is a possible saving in the costs of maintenance, depreciation and obsolescence.

These and many other questions are so hard to answer that every man from the top down needs the fruit of others' experience.

Industrial Piping provides the answer to these and many other perplexing problems. It is a case book describing actual conditions and remedies, written by nineteen engineers whose work in the field of industrial piping has been outstanding. Among the subjects discussed in this book are the following: calculating economical pipe sizes; calculating heat losses; special products available for special jobs; basic consideration in designing hangers; figuring comparative operating and upkeep costs of old steam piping system versus proposed modernized system; formula for figuring friction of steam through pipes; method of balancing the practical and the theoretically perfect calculations for pipe sizes; bending formulas for five types of bends; figuring thickness of insulation material to be applied to flat surface; figuring thickness of two insulation materials to be applied to a flat surface; figuring thickness of insulation to be applied to piping; figuring loss of head of viscous materials through pipe; choosing piping system for oils; installing high and low pressure traps on the same job; arranging piping for easy cleaning.

The book contains 286 pages, size $5^1/_2 \times 8^1/_2$, including a comprehensive index. Price $3.50.

Problems in Human Engineering

By F. Alexander Magoun

HERE is a real case book in Human Engineering, built around fifty typical difficulties and emergencies that business men have actually had to face. The questions are those that confront men in all ranges of business success, involving relations with superiors, equals, competitors, inferiors, customers, labor and the opposite sex. Almost every personality trait that can help or hinder a man at work is brought into the limelight of discussion.

What would you do if your department head asked you to corroborate a lie intended to cover up his own carelessness? What would you do if your research director took some of your work and published it under his own name? What would you do if one of the firm's biggest customers came storming in to cancel an order and you—still an underling in the organization—were the only person there to handle him? What would you do if an emergency call came through demanding that you work overtime on the very evening when you had an engagement that you couldn't break without serious embarrassment? How would you manage to get an interview with a man whom it was essential that you see and who had repeatedly refused to see you? How would you establish a better *esprit de corps* among the quarreling junior executives of an organization to which you had just come as president?

These are only a few of the knots the reader is called upon to untie. But he is given some help. Following the brief statement of the problem he finds a group of the actual answers which students in the Humanics class at the Massachusetts Institute of Technology that is being conducted by Professor Magoun worked out and handed in. Good and bad, pro and con, they have been selected to preserve the controversial nature which makes this problem book so stimulating.

This book contains 585 pages, size $5^1/_2 \times 8$. Price $2.60.

Stop That Smoke!

By Henry Obermeyer

THE smoke nuisance is still with us. Its damages, its dangers to life and property, its wastes, its ugliness—these are all still with us. And the toll of cost is tremendous. The author of this book sets forth the present condition conservatively, but with an overwhelming body of evidence. And he shows what has been done and what can be done to abate this nuisance.

In the preface to his book Mr. Obermeyer says, "A book such as this, written in non-technical language, by a layman from the public's point of view, was needed, in the judgment of the author, not so much to champion a cause which already has many distinguished champions in the scientific world, but to present, dispassionately, the picture of a condition which has grown upon us almost unaware. I have only three points to make. First, that an emergency actually exists; second, that it can be overcome; third, that we must overcome it by ourselves."

Stop That Smoke! will appeal to all civic agencies concerned with this problem. Its proposals are practical and specific. It will appeal no less to every creator of smoke, whether industrialist or householder, because it supplies technical hints on preventive measures.

The book contains 289 pages, size $5^1/_2 \times 9$, including bibliography and index. Price $2.50.

EQUIPMENT SALES

Boiler, Stoker, Pulverized Fuel

As reported by equipment manufacturers of the Department of Commerce, Bureau of the Census.

Boiler Sales

Orders for 108 water-tube and h.r.t. boilers were placed in August.

	Number	Square Feet
August, 1933	108	363,848
August, 1932	55	126,245
January to August (inclusive, 1933)	635	1,965,920
Same period, 1932	439	1,390,235

NEW ORDERS, BY KIND, PLACED IN AUGUST, 1932–1933

	August, 1932		August, 1933	
Kind	Number	Square Feet	Number	Square Feet
Stationary:				
Water tube	33	98,214	61	300,713
Horizontal return tubular	22	28,031	47	63,135
	55	126,245	108	363,848

Mechanical Stoker Sales

Orders for 213 stokers, Class 4,* totaling 40,644 hp. were placed in August by 42 manufacturers.

	Installed under			
	Fire-tube Boilers		Water-tube Boilers	
	No.	Horsepower	No.	Horsepower
August, 1933	153	17,877	60	22,767
August, 1932	99	13,229	38	12,827
January to August (inclusive, 1933)	623	80,491	299	110,847
Same period, 1932	548	72,797	267	107,106

* Capacity over 300 lb. of coal per hr.

Pulverized Fuel Equipment Sales

Orders for 18 pulverizers with a total capacity of 207,000 lb. per hr. were placed in August.

	Pulverizers				Boilers		
	Total number	No. for new boilers, furnaces and kilns	No. for existing boilers	Total capacity lb. coal per hour for contract	Number	Total sq. ft. steam-generating surface	Total lb. steam per hour equivalent
STORAGE SYSTEM — Water-tube Boilers							
August, 1933	4	4	..	160,000	2	72,432	1,120,000
August, 1932	..	..	..	.....	..	.....	......
January to August (inclusive, 1933)	6	4	2	220,000	4	109,432	1,445,000
Same period, 1932	5	1	4	11,250	5	17,400	110,500
DIRECT FIRED OR UNIT SYSTEM — Water-tube Boilers							
August, 1933	11	10	1	41,500	10	44,034	343,600
August, 1932	5	2	3	31,000	4	27,708	214,000
January to August (inclusive, 1933)	54	42	12	294,340	45	288,440	2,656,560
Same period, 1932	52	32	20	535,588	47	251,694	2,255,460
Fire-tube Boilers							
August, 1933	3	1	2	5,500	3	5,710	50,540
August, 1932	1	1	..	1,000	1	1,310	5,900
January to August (inclusive, 1933)	12	3	9	13,200	13	19,860	115,440
Same period, 1932	13	2	11	13,300	13	20,310	114,650

A Cubic Foot of Heat

By George P. Pearce

HEAT density seems to be one of the most misunderstood expressions in common use. In a certain heat-treating department the writer has often heard toolmakers and others, when peeping into a high temperature furnace, say, something like this: "Zowie! But there's a lot of heat there," when, as a matter of fact, the reverse is true. However, if you were to tell those persons that there is actually more heat in a bucket of cold water they would think you were trying to be funny.

The number of heat units in a cubic foot of anything, of course, depends upon what you are using for your zero of measurement. If you start at zero Fahrenheit, which is a convenient base, then a few approximate figures become not only interesting but useful.

Do you remember those sweltering days, three years ago, when it was 110 deg. in the heat-treating department right after noon? Well you might think there were plenty of heat units floating around, but that's where you are wrong; there were not. There were less than 2 B.t.u. per cu. ft. The temperature level was a bit high, that's all. Take the hottest spot in a gasoline torch and if one could make it fill a cubic foot of space there would be bottled up just about 10 B.t.u. The white hot furnace, approaching 2500 deg. has only 12 B.t.u. in every cubic foot and acetylene burning in air squeezes only 13 B.t.u. into the same space. The oxy-hydrogen flame when nicely adjusted steps up the concentration to 20 B.t.u. and its more powerful brother, the oxy-acetylene torch, only goes about 4 B.t.u. better with its 24 B.t.u. per cu. ft.

We get a surprise when we investigate the heat in a cubic foot of ordinary exhaust steam, which almost every factory throws away so casually, for we find it contains 50 B.t.u. per cu. ft; which shows how wasteful many folks are. Inside a modern steam main, where 240 lb. steam is superheated 300 deg., we really do begin to crowd the heat units for that combination crams close to 525 B.t.u. into every cubic foot, but, ridiculous as it may seem, common saturated steam at 235 lb. per sq. in. can beat that figure with around 657 B.t.u. per cu. ft.

And a chunk of melting ice can lick all of them for it will deliver around 8000 B.t.u. per cu. ft. if you cool it down to zero.

The homely bucket of boiling water is a very important heat reservoir for there you will find close to 10,000 B.t.u. in every cubic foot. The same space filled with melted sulphur at 800 fahr. holds almost 20,000 B.t.u. and melted aluminum at 1220 fahr. is hoarding between 60,000 and 70,000 B.t.u.

But the old fashioned arc lamp is the surprise member of our list. The heated carbon rod at its vaporizing temperature of 7000 fahr. packs a wallop of 500,000 B.t.u. per cu. ft. and that really is a lot of heat.

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